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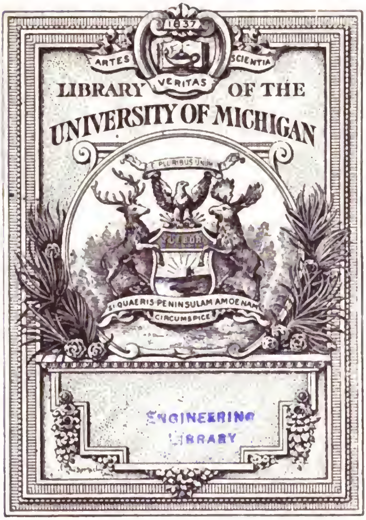

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INSTITUTION

OF

CIVIL ENGINEERS.

VOLUME I.

CONTAINING

ABSTRACTS OF THE PAPERS AND OF THE CONVERSATIONS

FOR THE SESSIONS OF

1837, 1838, 1839, 1840, 1841.

WITH AN INDEX FOR EACH SESSION.

LONDON:
PUBLISHED BY THE INSTITUTION:
TO BE HAD OF
MESSRS. LONGMAN AND CO., AND ALL OTHER BOOKSELLERS.

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MINUTES OF PROCEEDINGS

OF THE

INSTITUTION

OF

CIVIL ENGINEERS;

CONTAINING

ABSTRACTS OF THE PAPERS

AND OF THE

CONVERSATIONS,

FOR THE SESSION OF 1837.

LONDON:
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1837.

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1848.

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Stamford Street.

ADVERTISEMENT.

The Council feel it their duty to state most distinctly, that the Institution does not, as a Body, express any opinion approving, or disapproving the views advanced, either in the Papers or in the Conversations; such views, by whomsoever advanced, or howsoever here recorded, must be received entirely on the credit of their respective authors.

With regard to the statements recorded, but not attributed to any particular individual, the Council have only to remark, that a concise abstract of the Conversations could not have been made on a different plan. In the freedom of discussion which exists at the meetings of the Institution, many of the opinions advanced are canvassed in considerable detail, and it is the object of the Council to call attention to such statements as are of great importance to the Profession, and on which, consequently, the Institution is ever most anxious to receive accurate information, rather than to record the opinions of particular individuals.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1837.

ANNUAL REPORT.

The Council, on retiring from office, beg leave to lay before the Institution the following Report of the proceedings of the past year, and of the present state of the Society.

Among the events of the past year, the publication of the first volume of the Transactions especially deserves to be noticed. The appearance of this volume is a matter of the greatest congratulation to the members of the Institution, and an era to which all must look back with a high degree of satisfaction. The Council confidently hope, that the present volume is but the first of a series of Transactions, which will appear at regular intervals, and which, in practical utility and sound information on subjects connected with the profession, will be inferior to those of no scientific body in the world. With respect to the present volume, the Council cannot refrain from expressing their satisfaction at the extremely handsome form in which Mr. Weale has brought it before the public.

The Council would also dwell with peculiar satisfaction on the daily increasing interest which is taken in the welfare and success of your Institution; they believe that the time is fast approaching, when a general conviction of the advantage which must result from the periodical meetings of the members of the same profession, will induce all scientific men to unite in advancing the great objects which the original projectors of the Institution had in view, and which the Council has constantly laboured to promote. The numerous contributions which have been recently made to the Library of your Institution, show the anxiety which exists to promote the interests of this important department, and to supply abundant means for the advancement of scientific and professional knowledge.

The presents received have been numerous and valuable. The maps already published of the Ordnance Survey of Ireland (on a scale of six inches to a mile,) have been presented by His Excellency the Lord Lieutenant, (the Earl of Mulgrave,) who has also directed the remaining sheets to be sent as they are completed. There have also been promised to the Institution, by the Master General and the Board of Ordnance, a copy of the Ordnance Survey of England, and by the Lords of the Admiralty, the extensive series of hydrographical charts published under their direction.

The above presents show the estimation in which the Institution is held by various branches of the Government, and in addition to them many other valuable contributions have been made, which appear in the annexed list. The Council particularly request attention to a complete set of the Philosophical Transactions, consisting of one hundred and eighteen volumes, which the President (Mr. Walker) has added to the Library, and in the handsome present from Mrs. Page, of about three hundred volumes of books, with all the papers and plans relative to Civil Engineering, collected by her late husband, Colonel Page, an Honorary Member of the Institution, and also the manuscripts, copper-plates, notes, and other matter, for a work on Inland Navigation, which he had intended for publication. These, with the late President's (Mr. Telford) professional books and papers, have put the Institution in possession of perhaps the best collection in this, or any other country, on the subject of Inland Navigation.

But while so much has been done by others to advance the prosperity and add to the importance of the Institution, the Council trust that Members and Associates will not be wanting on their part, and that they will not fail to contribute such original contributions, before the commencement of, or during the approaching Session, as will prove the interest they take in this Institution. Accounts and drawings of works as actually performed, will be particularly valued, as well as papers of other kinds, and all will enter into competition for the Telford Premiums, which are adjudged to the communications best entitled to the honour: it is hoped there will be many such to occupy a conspicuous place in the Transactions, the first volume of which, after delays which have been in a great measure unavoidable, is now ready for delivery.

The Council have omitted no opportunity of endeavouring to procure apartments in Somerset House; hitherto their applications have proved unsuccessful, but the several departments of Government, having in many instances shown their readiness to promote the interests of the Institution, the Council are not without hopes that their request will ere long be attended to.

The Council regret that so much delay should have occurred in the production of the medals for the Telford Premiums; they have however the satisfaction of stating that the dies have been seen and approved, and that Mr. Wyon has promised to deliver the medals in three or four weeks.

The labours of the Library Committee have been carried on incessantly, and from the attention which has been bestowed on the important object which they have in view, the Council have reason to expect a most interesting report at an early period. A basis catalogue of the Library has been prepared by the Secretary, and will be laid on the table this evening; and the Secretary has made considerable progress with a descriptive catalogue of the Telford Papers.

The addition of corresponding Members, Associates, and Honorary Members, during the last session, is twenty-eight.

The Council have to lament the loss to the Institution of the following Members, deceased:—

Monsieur Navier, Honorary Member; Mr. Charles Landale, Corresponding Member; and Mr James Wyld, Associate.

The following gentlemen have resigned:—Mr. A. H. Holdsworth, Corresponding Member, and Mr. William Palmer, Associate.

The increase is therefore twenty-three, and the total number of Members two hundred and fifty-two; they consist of—

Honorary Members	14
Ordinary Members	47
Corresponding Members	93
Associates	98
Total . . .	252

The account of the Funds of the Institution is as follows:—

At the commencement of the last Session, (1836) the balance in the Treasurer's hands was £249. 8*s*. 3*d*.; since that period the amount of cash received has been £713 7*s*. 4*d*., making together £962. 15*s*. 7*d*.

The amount of cash paid has been £851. 11*s*. 4*d*., which, deducted from the former sum, £962. 15*s*. 7*d*., leaves a balance now in the hands of the Treasurer of £111. 4*s*. 3*d*.

Of the amount expended for the year 1836, the sum of £366. 15*s*. has been paid for the purchase of £400 Consolidated 3 per Cent. Annuities.

The Institution has now the following Stock :—

	£.	s.	d.
3 per Cent. Annuities (their own property) . .	535	3	8
3 per Cent. Annuities (Telford Fund) . . .	1945	19	0
Total	2481	2	8

The amount owing to the Institution by sundry Members and Associates is £208. 10*s*. 6*d*. up to December 31st last.

There is also a balance, not included in this sum, which has been some years in arrear.

In conclusion, the Council trust that the preceding Report will be received with great satisfaction; they consider that the prospects of the Institution are in every respect most favourable. The finances have steadily improved; a considerable amount of arrears has been brought in; but above all, the attendance at the Meetings has been far more numerous than in any preceding year. The Council are convinced that a general interest in the success of the Institution pervades the whole Society, and that all are united in the determination of advancing the Institution to a very high position in the scientific world.

ORIGINAL COMMUNICATIONS.

Baker, George. Description and model of a new Railway Chair.

Ballard, C. Description and model of a mode of framing Lock-gates.

Borthwick, M.A. Memoir on the use of Iron Piling, with drawings.

Bourns, C. Historical account of, and observations on the Port of London.

Bray, W. B. Drawings of the Pont des Invalides, the Pont de Jena, and the Pont du Carrousel, at Paris.

Bremner, J. Drawing and description of a machine used in forming the Harbour of Sarclet, Scotland, and drawing and description of a machine for clearing away sand from foundations, in harbour building.

Carnegie, Lindsey. Four drawings of Hunter's stone-planing machine.

Daglish, R. Drawing of a parallel rail and pedestals.

Hawkshaw, J. Paper on the mode of working Mines in South America.

Hopkins, Rice. Account of the Bodmin and Wadebridge Railroad.

Hopkins, T. Description and drawing of Ruthern Bridge, on the Bodmin and Wadebridge Railroad.

Marconi, E. Description and drawing of a proposed Floating Bridge, over the Vistula, to connect Warsaw and Prague.

Moreland, R. Drawing of an improved Mashing machine.

Morton, G. Description and drawing of a new Railway Carriage.

Page, Colonel. Papers on Canal navigation.

Perkins, Jacob. Three papers on the elasticity of Steam.

——————— On the causes of the difference of duty done by the Cornish and Soho engines, and on the improvement of Steam Boilers.

Reynolds, J. Description and model of an improved Railway.

Sibley, Robert. Mode of ventilating and lighting Tunnels, with a drawing.

Smith, George. On the effects produced by locomotive engines in Tunnels.

Taylor, John. An account of an experiment on the elastic force of Steam.

Thom, R. Results of experiments at Greenock and Rothsay with the Rain Gauges.

Waterston, J. J. Calculations and suggestions on Canal navigation.

——————— New mode of representing and estimating Excavations and Embankments.

Webster, T. On the relation between the temperature and elasticity of Steam.

Wicksteed, Thomas. Paper on the high-pressure engines working in the Cornish mines.

CATALOGUE OF PRESENTS.

BOOKS.

TITLE OF BOOK.	DONOR.
Anderson, W. Plan and report for the improvement of the Harbour of Leith . .	The Author.
Anonymous. Concession du Canal de Jonction de la Sambre à l'Oise	Mr. Musgrave.
———— Projet de perfectionnement de la Navigation de la Soane	Mr. Musgrave.
———— Report on the British Museum; by a Committee of the House of Commons	Mr. J. Simpson.
———— Report of a Committee on Mr. J. Martin's proposed plan for the improvement and conservancy of the Thames .	Mr. Whitwell.
Architectural Magazine	The Editor.
Architectural Society of Berlin, Transactions of .	The Society.
Baily, F. Report on the new Standard-scale of the Royal Society	The Author.
Blackadder, W. Report on the Strathmore Railway	The Author.
Board of Trade. Tables of the Revenue, Commerce, Population, &c. of the United Kingdom, 1834	The Board of Trade.
Bruyère, —. Etudes relatives à l'art de construction	Mr. L. Cubitt.
Cleland, Dr. Historical account of the Bills of Mortality in Glasgow	The Author.
Coldstream, Dr. Account of the structure and habits of the 'Limnoria terebrans'. .	The Author.
Day, J. Plan and description of a continuous-base Railway	The Author.

TITLE OF BOOK.	DONOR.
Delaistre, J. R. Encyclopédie de l'Ingénieur .	Mr. Whitwell.
Fairbairn, W. Account of the Reservoirs on the River Bann, Ireland . .	The Author.
Farey, J. Account of Mr. Woolf's patented inventions	The Author.
Fox, R. W. On the Dipping Needle Deflector.	Mr. A. Fox.
Fraser, —. Literary Chronicle . . .	The Editor.
Grahame, T. Letter on the present system of Legislation which regulates the internal intercourse of Great Britain . . .	The Author.
Lecount, P. On Iron Rails . . .	Mr. Aitchison.
Lyell, C. Principles of Geology . . .	Mr. W. Cubitt, V.P.
Macneill, J. Plan of a proposed Railway from Berwick to Glasgow; and the late Mr. Telford's report upon it, 1810 . .	The Author.
——— Account of the proposed Stirling Canal; with Mr. Macneill's report on the project	The Author.
Manchester, Mechanics' Institute. Report of the Directors, 1835	The Directors.
Millard, J. Letter on the management of the British Museum	The Author.
Milne, J. Plans for the improvement of the Port of Leith	The Author.
——— Observations on the Tides of Leith, with a chart of the Firth of Forth . .	The Author.
Navier, M. On the comparison of Railroads; translated by J. Macneill . . .	Mr. Macneill.
Nicholson, —. Architectural Dictionary .	Mr. Thomas.
Page, Colonel. A collection of numerous works on Engineering subjects, Tracts, &c. .	Mrs. Page.
Parliamentary Report. Minutes of Evidence on the Great Western Railway . .	The Colonial Office.
Pambour, Chevalier. On Locomotive Engines upon railways	Mr. Weale.

TITLE OF BOOK.	DONOR.
Parker, J. W. Magazine of Popular Science .	The Publisher.
Parnell, Sir H. On the construction of Coaches.	The Author.
Phillips' History of Inland Navigation . .	Mr. Gordon.
Ravinet, —. Dictionnaire Hydrographique de la France	Mr. Musgrave.
Rennie, G. Report on the progress and present state of our knowledge of Hydraulics as a branch of engineering	The Author.
Richardson, J. Report on the Tyne and Clyde.	The Author.
Royal Society. Transactions of the Royal Society of London: the complete set from 1665 to 1831; 118 volumes . . .	Mr. J. Walker, President.
Schauffelen, G. Description of a hot air Furnace feeder	Mr. J. Simpson.
Simms, F. W. A Treatise on Mathematical Instruments	The Author.
Sopwith, J. Treatise on Isometrical Perspective.	The Author.
Stevenson, D. Observations on the Manchester and Liverpool and the Dublin and Kingstown Railways	The Author.
Stevenson, A. Report to the Commissioners of Northern Lighthouses, on the new Dioptric light at Inchkeith	The Author.
Tredgold, T. On the Steam Engine . .	Mr. Gittins.
Webster, T. The principles of Hydrostatics .	Mr. F. Bramah.
——— On the Theory of Fluids . .	The Author.
Wright, G. N. A new and comprehensive Gazetteer	Rev. G. N. Wright.

MAPS AND PRINTS.

Maps. Collection of the late Colonel Page .	Mrs. Page.
—— Ordnance, of Ireland. Counties of Londonderry, Tyrone, Down, Fermanagh, Monaghan, and Armagh	Lord Lieutenant of Ireland.
—— Of London and Birmingham Railway.	Mr. Cheffins.

	DONORS.
Maps. Three Maps of Canals in France and Flanders	Mr. Musgrave.
—— Map of the North of France, with Statistical Tables, by M. Jodit . . .	Ditto.
Bridges. Four Views and Plan of Bow Bridge.	Mr. Burges.
—— Elevation of the Pont du Carrousel .	Mr. Bray.
Buildings. Plan of Parliamentary and other Buildings adjacent to Westminster Hall .	Mr. Richardson.
—— Section and Elevation of one of the principals in the Roof of Westminster Hall	Mr. Freeman.
—— Public Works of Prussia . .	The Prussian Consul.
Docks. Two Plans of Dundee Docks . .	Mr. Leslie.
Railroads. View of the Opening of the Bodmin and Wadebridge Railroad . . .	Messrs. Hopkins.

SPECIMENS.

Concrete. A portion from the South wall of the Tower of London	Mr. Tucker.
Granite. Fifteen kinds of, and Table of results of Experiments made to determine their relative strength	Messrs. Freeman.
Stone and Slate. Planed with Hunter's Machine.	Mr. W. Freeman
—— Valencia Slate, and an account of the Experiments made to compare its strength with that of Yorkshire Stone .	Messrs. Freeman
Timber. Specimens from Yarmouth and Bridlington Piers, showing the destructive effects of worms	Mr. J. Walker, President.
Valves. One of those employed in the compression of Gas by D. Gordon . .	Mr. A. Gordon.

OFFICERS.—1837.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1837.

January 10, 1837.

JAMES WALKER, President, in the Chair.

Cements.

The President, having called the attention of the members to the conversation on Cements which had taken place at the last meeting of the past session, requested Colonel Pasley, who had made many extensive experiments on this subject, to give some account of the results at which he had arrived.

Colonel Pasley.

Colonel Pasley said, that his attention had been directed to the subject of Cements, from reading in Smeaton's works, that all water limes were composed of carbonic acid and clay; since, on dissolving these limes in carbonic acid, clay, of which brick could be made, was left. From this remark he had been led to make experiments similar to the following: he took two parts of chalk and one of clay. The chalk being pounded and mixed with the clay, balls were formed, which being burnt in a crucible, were ground and mixed as cements usually are. Some of these experiments failed, but he attributed their failure to his having used clay which was coarse and sandy; whence it appeared, that substances would unite, when in the form of a fine powder, which would not unite when in a coarser form. These experiments were made in the years 1829, 30, 31, and 32. Subsequently, in 1836, he repeated his more successful experiments, but without the same success; and he attributed their failure to the fact of the clay (the blue clay of the Medway,) containing a greater proportion of carbonate of lime, than it had contained five, or six years before. Continuing his experiments, he found, that 4 lbs. of dry chalk and 5 lbs. of the moist blue clay, fresh from the Medway, made the strongest cement; but he had determined many other proportions which set immediately under water. With cement made according to the above proportions, thirty-one bricks had been set out from a wall, one brick being added every day, omitting the Sundays.

He had cemented bricks together, and he found in every case, that the bricks gave way and not the cement. He estimated the breaking force at the joints, at about 5000 lbs. on the 36 square inches, the surface of the brick. On comparing the strength of this cement with the chalk mortar, which had united some bricks, more than thirty years, he was led to consider the adhesive power of his artificial cement, forty days' old, as at least twenty times greater than that of the mortar.

January 31, 1837.

WILLIAM CUBITT, V.P., in the Chair.

"Description and Drawing of an Apparatus designed by Mr. Mitchell for Boring Wells." By Mr. Mitchell, Jun., of Sheerness.

Boring Apparatus. This apparatus consists of a frame, similar to that of a pile engine, in which the rods are suspended; on one of the rods is a wheel fixed on a square spindle (through which the rod can slide), and turned by means of a pinion and crank; the axis of this pinion serves also to draw the rods, since they may be drawn up by a single rope, or by a tackle suspended to the top of the frame, the rope of the block passing round the winch. The auger is regulated in the cut by a screw and nut; thus the rods are always kept from bending in the hole, and the bore from getting out of the perpendicular. This apparatus is found peculiarly convenient in chalk, and when stones are met with; since in most cases, if the auger be sufficiently hard, the stones flash off in small chips similar to gun flints.

"A Method of breaking Ice, by forcing it upwards instead of downwards; practised on the Herefordshire and Gloucestershire Canal, in the Winters of 1834–35 and 1836." By Stephen Ballard, Assoc. Inst. C.E.

Ice Boats. Mr. Ballard places strong planks, covered on their upper side with sheet iron, in the front of a boat, so as to form an inclined plane pointing downwards, the lower end projecting under the ice. The boat, drawn by a horse, is steered by a person walking on the shore, with a long shaft attached to a pole projecting over the stern. It is believed that one boat, a horse, and a boy, would thus break much more ice than three boats worked in the usual manner.

Cements.

Mr. H. H. Price called the attention of the Institution to the importance of ascertaining, what were really the constituent elements of Artificial Hydraulic Mortars and Cements; several memoirs had been read before the Institute of France on the subject; but they exhibited great discrepancies, as to the principles of the formation of those cements. It was of the greatest importance to the engineer, to know from the materials at hand, how to make a cheap average hydraulic mortar.

Colonel Pasley.

Colonel Pasley remarked, that he considered Smeaton's Researches* as the only ones of value; the French philosophers had followed out many of his suggestions in great detail. Two systems appeared to have been pursued in France, the one, in which the substances were burnt previously to their being mixed, the other, in which they were mixed in a state of minute division previous to their being burnt. The Aberthaw limestone used by Smeaton, consisted of carbonate of lime and clay; 1 part of the lime from this stone, and 2 parts of sand, made a cement which set very hard in time; but the joints required to be protected at first by Sheppey, or some similar cement.

Mr. Lowe.

Mr. Lowe was of opinion, that very much must be attributed to the presence of silica; this evidently played a most important part. Limes had exceedingly different qualities; two makers using the same quarry would produce very different limes; if lime was flare-burnt, that is, burnt at a white heat, all the carbonic acid was driven off suddenly; the properties of lime burnt at a slow heat would differ much from the properties of the preceding. The mechanical mixing was also of the greatest importance; the Barrow lime was a natural hydraulic lime, but it must be well beaten with water and silica, or sand.

Surveying Signals.

Mr. Blunt, (America,) gave, at the request of the Chairman, an account of the system of signals, which were employed in the geometrical operations now carrying on in America.

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* Vide Smeaton's *Edystone Lighthouse*, Arts. 148—206.

February 7, 1837.

The PRESIDENT in the Chair.

Cements. The conversation on Artificial Cements being resumed, several members expressed their opinions, on the causes to which the hardening of mortar was to be referred. Hydrate of lime was stated to be the basis of all mortars; but this would not make a water mortar, or cement, without the addition of a metallic oxide. The addition of clay would effect this, but most clays contained a metallic oxide.

Mr. F. Bramah. Mr. Francis Bramah gave the analysis of Dutch Terras, of Basalts, and of Puzzolana, according to different experimenters; in all these there was a considerable proportion of iron, and the addition of any of them to hydrate of lime, would make a water mortar. Thus it appeared, that we must carefully distinguish between a good mortar, and a good water mortar, or cement. Hydrate of lime was the basis of both. Good mortar depended for its excellence on the slow absorption of carbonic acid, and the slow absorption of this was, according to Tennant, the essential condition for good mortar. According to Pliny and Vitruvius, the Romans kept their mortar for three years, and it was now the custom among builders to bury mortar, or to keep it in a cellar; it was thus prevented from absorbing carbonic acid from the atmosphere, or, in other words, from being reconverted into limestone. According to some experiments of Tennant, it appeared, that mortar in three years and a quarter would regain 63 per cent. of the carbonic acid, of which it had been deprived. The absorption of carbonic acid being the condition of mortar hardening, if it were used under such circumstances that this absorption could not take place, as under water, some other material must be supplied, and the addition of a metallic oxide appeared to supply the required element.

Mr. J. I. Hawkins. Mr. Hawkins stated, with respect to an hypothesis of Kirwan's, which had been mentioned, as to the peculiar properties of iron and clay, a singular fact, which had come under his own observation, namely, that the rust of iron had a peculiar disposition to travel through moist clay; the rate of this transfer was in one case about one inch per month.

"On Locomotive Engines and the means of supplying them with Steam." By Jacob Perkins, M. Inst. C.E.

Locomotive Engines. The object of this paper is to show how Locomotives may be supplied. The practical defects of the present system of Locomotives, arising from the furring up, or burning out of the tubes of the boilers, Mr. Perkins proposes, that steam should be generated, through the medium of steam surcharged with caloric. He states, that if a tube, hermetically sealed, be filled to one-sixtieth of its content with water, the steam arising from the water, will not acquire sufficient elastic force to burst the tube: but will have a remarkable property of transferring heat. The steam within the vertical tube being saturated with heat, becomes a medium through which the heat ascends by its own levity, so that the top of the tube would become red hot, were it not immersed in water. The difference between pure and surcharged steam is, that the latter gives up its heat without condensing it, whereas the former must necessarily be condensed as it parts with its heat. Mr. Perkins states, that a boiler has generated steam on this principle, under the action of ardent heat during the last seven months, and without the least leakage, or incrustation.

Mr. Perkins then details the advantages, which may be gained from the adoption of this principle, and proceeds to make some remarks on the manufacture of locomotives. He recommends the division of labour in the workshop;—that the engines should all be fac-similes; and that parts be manufactured at the places best adapted for their production. The paper concludes with observations on the most effective application of steam; on the best velocity of the piston, and gives relative proportions for the diameter and length of the cylinder.

American Steamers.

Mr. Blunt, (America,) at the request of the President, stated some facts respecting the American steamers.

The double boats had been given up, and the average speed of the best boats was 15 miles per hour. One boat, whose length was 220 feet and breadth 18 feet, had a greater average speed than the preceding.

They had recently introduced a ferry-boat, which might, he conceived, be extremely serviceable in our rivers; in the Thames, for instance, where there were a great number of vessels. The ends of the boat were similar, with rudders at either end, which were worked by one midship steering wheel; the boat could thus go either way. The rudders were placed in a semicircular chamber at each end, and could be reversed; they were worked by a chain passing round the wheel of both and crossing in the middle, so that the boat was brought about by the contrary action of the two end rudders. The wheel and chain could not get out of order, and the top of the rudder was below the water, so that the boat could go through the broken ice. Such a ferry boat would go about in her own length, which was about 100 feet.

Mr. Blunt had repeatedly gone, in five hours, a distance which he knew, from actual trigonometrical measurement, to be 74 miles. The boats completed the distance from New York to Albany, which was not less than 150 miles, in ten hours. The speed of these boats, as compared with that of the boats in this country, was not to be wondered at, when it was remembered that they were built simply and expressly for speed. The Americans paid great attention to the form of their boats; the water was smooth; the engines were placed on the deck and the boilers on the wings; and they spared no expenditure of power, provided speed could be obtained.

February 14, 1837.

The PRESIDENT in the Chair.

"Description of Mr. Henry Guy's method of giving a true spherical figure to balls of Metal, Glass, Agate, or other hard substances."* Communicated by Bryan Donkin, V. P. Inst. C.E.

True Spherical Balls.

The method adopted by Mr. Guy consists simply in the practical application of the principle, that if a ball can be made to revolve rapidly in every possible direction, or, in other words, if during such revolution its axis of rotation be constantly changing its angular position within the ball itself, whilst a grinding tool is applied to the surface of the ball, the most prominent parts of that surface will be first acted on by the grinder, and by continuing the operation, the whole of the higher parts of the surface will be progressively ground off, and the ball will ultimately assume a perfect and spherical form.

Mr. Guy effects this, by placing the ball betwixt the faces of two wooden chucks, fixed to two lathe mandrils, such as are used in common turning lathes, with their axes exactly in a line with each other. A quick motion is given to the mandrils in the usual way by two bands, so applied that the mandrils are turned in opposite directions: the ball being compressed betwixt the chucks, turns, notwithstanding the friction of the tool. The tool is a bar of brass, or iron, with a conical hole near one end, the larger diameter of which is made a little larger than the diameter of the ball.

"On the Construction of Railways of continuous Bearing." By John Reynolds, Assoc. Inst. C.E.†

The Author states the conditions essential for a good railway to be; 1°. That it should be the closest practical approximation to a perfect plane of perfect stability. 2°. That it should be adapted to prevent, or to neutralize, the vibrations, arising from the impact of imperfect cylinders rolling on imperfect planes. 3°. That it should possess the greatest durability and the greatest facility of being repaired, which are compatible with the above conditions.

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* Vide Trans. Inst. C.E., vol. ii., page 47.

† Ibid. page 73.

Mr. Reynolds proposes continuous trough-shaped cast iron bearers, having rectangular bearing surfaces, the angular point being downwards. Thus a section of the bearing part of the rail across its length is a right angle, with its vertex downwards. By this peculiar shape, the sustaining area is increased, a greater resistance to vertical pressure is consequently obtained, and the lateral stability of the rail is secured. The rails are to be laid in earth, ashes, or broken stone and gravel, and the sustaining surface of the earth may have any requisite density communicated to it, by rolling, or beating the earth at the sides, so as to give it sufficient density to resist the pressure to which the rail is to be subjected. The mass being composed of materials which will not readily yield, or slip away, will be incapable of further condensation, by any subsequent pressure, not exceeding that to which it had been originally subjected by the bearers, or rollers acting at the sides.

The rails used by Mr. Reynolds are of two kinds; rails wholly of cast iron, cast in one piece, and rails either of wrought, or cast iron, laid on a cill of wood; the wood being placed in a cast iron bearer of the shape already described. The rails, cills, and bearers, in this latter construction, break joint with each other, and are held together by bolts passing through all three. Thus one continuous structure is formed throughout the whole line, and the fracture of the three parts in the same place is highly improbable. The vibrations will be neutralized by the cill of wood acting as a partially elastic cushion, in receiving the concussion to which the rails are subjected. This latter mode of construction is considered preferable, as admitting of the use of either cast, or wrought iron rails.

February 21, 1837.

BRYAN DONKIN, V.P., in the Chair.

The construction of Railways on the principle of continuous bearing, as adopted by Mr. Reynolds, and described in his paper read at the last meeting, was discussed. Some of the rails and bearers cast in a single piece, having been laid on Chatmoss, inquiries were made as to how they had answered. It was stated that they were kept in order with less trouble than the others, and that they did not **Railways.**

exhibit any tendency to sink. It was intended to use the commonest timber for the cills; the wood having been boiled and allowed to cool in tar, became so saturated with it, that it would not subsequently imbibe any moisture.

"A Steam Expansion Table." By George Edwards, M. Inst. C.E.

Steam Table.

In the paper explanatory of this table, the Author remarks, that it has become a matter of interesting inquiry, why the expansive property of steam is as yet so little used, when attention has been so much directed to it, by economizing fuel by improved boilers, and other similar means; and the more so, as patents were taken out by Hornblower in 1781, by Watt in 1782, and by Woolf in 1804, for working steam expansively. The objections to the use of high pressure steam may perhaps be an obstacle, but there are many cases, as in the engines of tug-boats, to which these objections cannot apply.

Very incorrect notions having existed of the expansive properties of steam, the Author has, according to the admitted law, "that (the temperature being constant) the bulk is inversely as the pressure," constructed a table, showing at one view, the resulting pressure, on the expansion of a given volume of steam of given density, and vice versâ.

The Author then describes the construction and method of using the table, so as to answer at once questions similar to the following: "Required, the pressure of 50 lbs. steam when expanded to three times its volume?"

"In a high-pressure engine, working expansively, required the length of the stroke at which to cut off the steam, that the pressure may be 14 lbs. at the end of the stroke?"

"In a Woolf's engine, working 54 lbs. steam, required the capacity of the larger cylinder, the smaller being unity, so that the pressure of the steam shall be 4 lbs. on the completion of the stroke of the large piston?" &c. &c.

With respect to the principle on which this table was calculated, it was stated, that the temperature did not remain constant, and that the pressure fell off most rapidly on the steam being cut off, and reference was made to some experiments made by Mr. John Taylor on this subject, and mentioned at the meetings of March 1st and 8th, 1836.

February 28, 1837.

The PRESIDENT in the Chair.

"On a peculiar form of Rail, and the construction of Railways in America and Germany." By Herman Koehler, (of Leipzig,) M. Inst. C.E.

Railways.

The pattern, which the Author describes, is by American engineers called the inverted ⊤ rail (⊥),and was introduced, in order to avoid the trouble and expense, which railways are liable to, where the rails are placed in chairs and fastened with keys. The material used for this form of rail need not be of first quality; but in cases where it is expedient to support a general confidence in the quality of the iron, good and sound rails can be made of two-fifths of No. 2, Welsh iron, and three-fifths of No. 3; employing the better quality for the head and the bottom, and No. 2 for the stem of the rail; rolling the rails in such a manner that the laminæ of the iron shall lie horizontally throughout.

The experience derived from the working of railways, seems to confirm the opinion, that chairs and keys, to keep the rails firm to their places, are expensive and inconvenient, and that they form a dangerous construction, whether wood or iron be the material of the keys.

The Author then details the advantages of this form of rail, especially if laid on a continuous line of stone,or of wooden sleepers at small distances apart.

Wooden railways are at this time used in Germany, and the Author has so constructed a length of 9 miles betwixt Leipzig and Dresden. Wooden sleepers, 8 inches square, are placed in trenches cut across the embankment at intervals of a yard apart, with a bed of broken stones one foot deep beneath them. Notches 3½ inches deep, are cut into these cross ties, to receive the wooden rails of 6 inches by 9 inches, which are shod with iron plates of 1 inch thick, by 2½ inches wide. At the joints, they are put together on iron plates one-eighth of an inch thick, to prevent their being pressed into the wood. The timber rails are wedged firmly to the sleepers by wooden wedges. The heads of the spikes, with which the iron rails are fastened to the timber, are of a conical form and fit into corresponding holes, which are of an elliptical form, to prevent the spikes from being drawn, or bent, on the contraction or expansion of the iron rails. The ends of the iron plate rails are fastened with screw bolts, passing through the whole depths of the wooden rails, holding them firmly to their places; this is a very important precaution, as the flanches of the wheels are apt to catch the points of the plate rails, and thus to throw the engines and carriages off the line.

"A drawing and description of a new Lewis." By Henry Robertson (Glasgow.)

New form of Lewis.

The proposed Lewis consists of two pieces of iron, whereof each is a bent lever connected at a joint by a strong bolt. When the upper, or longer arms are drawn together, by the tension of the lifting chain, the under, or shorter arms, inserted into the hole, are forced against the sides, and by properly increasing the proportion of the upper to the under arm, any necessary power may be given to the instrument.

The advantages of this Lewis, as compared with those composed of three pieces, as usually constructed, are, that it can be inserted into and removed from the hole in less time; it adapts itself to the form of the hole, all fitting and plugging with slips of iron being unnecessary; and by exerting its pressure directly against the sides of the hole, it is less liable to chip off the edges and to endanger the falling of the stone.

"Experiments on the strength of various kinds of American Woods, exposed to a transverse strain."* By Lieut. Denison, R.E., Assoc. Inst. C.E.

Strength of Timber.

These experiments were principally undertaken, with the view of establishing some common standard of comparison between the woods in general use in America and in England. Some of the results corroborate, in a remarkable degree, the experiments made by Mr. Barlow upon wood of the same nature; but of very different scantling, and under different circumstances.

The results are given in a series of tables, and the calculations are according to the formulæ given by Mr. Barlow.

March 7, 1837.

The PRESIDENT in the Chair.

"Account of a Machine for cleaning and deepening small rivers, in use on the Little Stour River, Kent."† By W. B. Hays, Assoc. Inst. C. E.

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* Vide Trans. Inst. C.E., vol. ii., page 15.

† Ibid. page 181.

River Cleaning Machine.

The mode of application of this machine, to scour out small river, consists in taking advantage of an artificial head of water, with the assistance of a small current, to force on a boat armed with scrapers.

At the stern of the boat a vertical frame is lowered, with scrapers at the bottom, and to the sides of the boat, near the stern, are attached wings, which on being opened out form a dam. Thus a small head of water being obtained, the boat is forced forwards, and the mud and weeds are carried down to the mouth of the river by the action of the scrapers.

"Drawing and description of a wooden Bridge erected over the River Calder, at Mirfield, Yorkshire,"[*] By William Bull, Assoc. Inst. C. E.

Wooden Bridge.

This arch, which is composed of two ribs of fir timber, is 147 feet 6 inches span, 11 feet versed sine, 5 feet wide at the centre and 8 feet at the abutments.

"On experiments on the strength of Materials." By Thomas Webster, M.A.; Sec. Inst. C.E.

Strength of Materials.

The object of this paper was to point out the importance, in making experiments on the strength of materials, of beginning with weights sufficiently small. In the series of experiments on the strength of various timbers by Lieut. Denison, which was laid before the last meeting of the Institution, the first weights were in some cases too large; for, from the commencement, the deflection increased more rapidly than the imposed weight.

The points to be ascertained in all experiments of this kind were; first, the weight which a beam could bear, the elasticity being unimpaired, or the Elastic Weight; and, secondly, the Breaking Weight.

So long as the deflection increased, in exact proportion with the increase of the weight, the elasticity might be considered to be unimpaired; but if the deflection increased in a higher ratio, that is, if the deflection for one cwt. was one inch, and for two cwts. more than two inches, it might be suspected, that some violence was done to the elastic force of the material. Thus a guide was furnished for observations; the weight before which this ratio was observed to change, must be considered as the Elastic Weight. When a beam was to be broken, the effect of time should be noticed, and the increased deflection, after a given number of seconds, should be recorded.

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[*] Vide Trans. Inst. C.E., vol. ii., page 87.

The experiments of Lieut. Denison bore out these remarks; for it would be seen, that the point at which he had noted the first permanent set, was in many cases, immediately after the change, which was here laid down as the condition for determining the Elastic Weight.

Mr. Cottam.

With respect to the strength of materials, Mr. Cottam stated, that it had often occurred to him, whether, if a beam was loaded by ever so small a quantity beyond the Elastic Weight, this beam would not in time be broken. This consideration might, he thought, explain some apparent difficulties, as when a beam broke suddenly, without any increase in the weight, having been loaded to the same amount for many years.

Mr. Hawkins.

Mr. Hawkins mentioned a case, in which a beam that deflected too much, had been sawn down in its middle and bolted up, so that its depth was increased in the centre from 10 to 11 inches. The effect of this was that the deflection, instead of being about $1\frac{1}{2}$ inch, was only $\frac{1}{8}$th of an inch. Was this great increase of strength to be attributed to the increase of depth simply, or to the lower half having become a truss and the upper a strut?

March 14, 1837.

The PRESIDENT in the Chair.

Decay of Timber.

The decay of Timber in contact with stone, was discussed, and several instances were mentioned, in which the only decayed part of timber, was that which was in contact with stone. It was stated, that this decay was entirely obviated, by inserting the wood in an iron shoe, or by placing a thin piece of iron betwixt the wood and the stone. Several cases were mentioned, in which the iron shoe had been found a complete protection against dry rot and decay; a hard crust was formed on the timber in contact with the iron, which seemed effectually to preserve it. It was suggested, that the system of grouting must contribute to the early decay of timber; and that bond timbers had, consequently, been in many instances replaced by bond irons. Bond timber was used very generally at Manchester, and answered exceedingly well, but it was suggested that the high temperature of the buildings might be a preventive against the decay of the timber, as the walls were very soon dried.

The subject of the strength of materials was resumed, and especial reference was made to the experiments by Mr. Hodgkinson, on the strength of iron girders, published in the Transactions of the Manchester Society. In his paper Mr. Hodgkinson supposed the forces of extension and compression to have a ratio 1 : *n;* and not, that within the elastic limit at least, this ratio was a ratio of equality. Also, those experiments were directed especially, to determining the form of beam which would be strongest, up to the instant of fracture; or, in other words, the beam which would have the greatest breaking weight, without any reference to the elastic weight.

Strength of Materials.

These principles were contrary to those laid down by Tredgold, and to the opinions of many persons of great experience.

Mr. Donkin and Mr. Francis Bramah maintained, that within the elastic limit the forces of extension and compression were equal; that consequently, within this limit, the deflection would be the same, whether the beam was laid with a particular edge highest or lowest; that a beam, for instance, whose section was a triangle, would exhibit the same deflection within the elastic limit, whether the vortex, or base of the triangle was placed uppermost; beyond this limit, however, the case was different.

Mr. Donkin and Mr. F. Bramah.

The strength of a beam, according to Mr. Hodgkinson's experiments, depended on the bottom flanch; by increasing this, he had made beams, for which the breaking weights were 4000, the square inch of surface of section, whereas Tregold's strongest forms were about 2500, the square inch.

March 21, 1837.

The PRESIDENT in the Chair.

"On the strength of Iron Girders." By W. B. Bray, Assoc. Inst. C.E.

In this paper the Author states the rules which had been given by Galileo, Tredgold, and Hodgkinson, for calculating the strength of iron girders. He showed by a table, that Galileo's rule must be utterly false, when applied to girders having large bottom flanches. Applying this rule to two girders, one of which contained double the metal of the other, they ought to be of the same strength, whereas Mr. Hodgkinson's rule made the former only one-half as strong as the latter. Tredgold gave no rule for the case of a large bottom flanch. Thus there appeared to be great inconsistency in these rules, and a formula applicable to all cases was still wanted.

Strength of Iron Girders.

"On Mr. Hodgkinson's experiments on Cast Iron Girders." By Thomas Webster, M.A.; Sec. Inst. C.E.

Iron Girders.

The object of this paper was, to detail the result of an examination of the above experiments, undertaken with the view of ascertaining whether those forms of beams recommended by Mr. Hodgkinson, as requiring greater breaking weight, had also a greater elastic weight than the more ordinary forms, with equal flanches at the top and bottom. The principle assumed by Tredgold (which also was the principle assumed by Dr. Young,) was, that within the elastic limit the forces of extension and compression were equal; whereas Mr. Hodgkinson started with the inquiry as to the law which connected the forces of extension and compression.

Mr. Hodgkinson's experiments must be viewed, as directed entirely to determining the breaking weights, and the earlier weights were not set down in many of the experiments. The weights and deflections first recorded, were in many cases, very near the elastic weight and the point of permanent set, so that there was great difficulty in applying the principle already laid down,* for determining the elastic weight. But in some of the experiments which had a long series of early weights, it would be seen, on comparing the increase of deflection, with the increase of weight, that this ratio changed from one of equality, sooner in these forms, than in those with equal flanches at the top and bottom. If then, the beams with large bottom flanches did possess practical advantages, it might be, from their allowing a violation of the elastic limit, with comparative safety; this was however, a state of things which ought never to be contemplated.

April 4, 1837.

BRYAN DONKIN, V.P., in the Chair.

"Results of experiments, made with a view to determine the best figure and position for Wooden Bearers, so as to combine lightness and strength." By James Horne, F.R.S.; Assoc. Inst. C.E.

Wooden Bearers.

The results of several experiments on wooden bearers of different sections were tabulated in this paper; together with the dimensions and weights of the pieces, and the nature of the fracture. The conclusion at which Mr. Horne arrived was, that a triangular prism, placed with its base upwards, was the strongest figure and position; and that with an edge uppermost was the weakest, for a given quantity of material.

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* Vide ante, page 27.

Vibrations of the Soil.

The subject of the vibrations, produced in the soil by the passage of Locomotives and Coaches was discussed, and several instances were mentioned, in which the vibration of the soil was sensible, at the distance of a mile and a half, during an observation by reflexion. It was stated, that the experiments recently made, for determining the effect which the passage of the locomotives at a small distance, might have on the observations at the Royal Observatory, had not been conclusive; but that as no sensible effect could be produced on any observations, but those by reflection, no apprehension of inconvenience might be entertained.

It was also stated, that a number of persons running down the hill in Greenwich park, produced a slight tremor, which was quite sensible during an observation by reflection, and that the shutting of the outer gate of the Observatory threw an object completely out of the field of the telescope.

Raising Water.

The comparative merits of the Single-acting Engine and of the Crank Engine, for the purposes of raising water, were discussed.

Mr. Simpson stated, it was a generally received opinion, that a single-acting engine would do one-third more duty than, a crank engine: but that recently he had a crank engine altered by Messrs. Maudslays and Field, and being fitted with expansion valves, it did more duty than the single-acting engine. The two engines were worked from the same boiler. The duty of the crank engine was about thirty-two millions; it worked to a fixed lift, which was in some respects advantageous. The duty of the Cornish engines was reported as ninety-five millions, and an engine near London in which the Cornish valves and system of clothing had been adopted, was doing a duty exceeding fifty millions.

With respect to the Cornish engines, it was stated that their superior duty was due to the system of clothing; that although many persons had examined their duty, the calculations appeared to be made from the contents of the working barrel; that the Cornish bushel was 90 lbs. or 94 lbs. of a very superior coal; the London bushel being only 80 lbs. or 84 lbs.; that notwithstanding the great duty done by the pumping engines, the crank engines in Cornwall were doing less duty, than the crank engines in London.

"Notice concerning the Thames Tunnel." By Richard Beamish, M. Inst. C.E.

Thames Tunnel.

The paper states that several attempts had been made in former years to effect a communication betwixt the opposite shores of the Thames by means of a tunnel, all of which, however, failed. In 1798, Dodd proposed a tunnel at Gravesend; in 1804, Chapman projected one at Rotherhithe; and in 1807, Vazie commenced the construction of a shaft, 11 feet diameter, at a distance of 315 feet from the river. With Vazie was associated Trevethick, a man of great practical knowledge as a miner, and by indefatigable labour, a drift-way 5 feet in height, 2 feet 6 inches in breadth at the top, and 3 feet at the bottom, was carried 1046 feet under the river. In the spring of 1808, having first ascended from under a rocky stratum, though with a depth of at least 25 feet betwixt them and the bed of the river, the Thames broke in upon them, and not a single brick having been laid, the work was irretrievably lost.

In 1823 the subject of a tunnel was again agitated, and a company was formed, to carry into execution the plans of Mr. Brunel. The first proceeding was to sink a shaft. Twenty-four piles, with a shoulder on each, were first driven all round the circle intended for the shaft. One side of a wooden platform, or curb, was then laid on this shoulder, whilst the other side rested on an iron curb, having an edge below to which it was attached. Through this curb ascended forty-eight wrought-iron bolts, 2 inches diameter, to the height of 40 feet, the height to which it was proposed to raise the shaft. The regular building of the tower on the curb, with bricks laid in cement, was proceeded with, and yet farther bound together by twenty-six circulur hoops of timber, half an inch thick, as the brick-work was brought up. At the top of the tower was placed another curb, and the long iron bolts passing through it, having their ends formed into screws, the whole was screwed solidly into one mass, and completed in three weeks. In a week after it was finished sixteen of the piles having been driven, two by two, opposite each other, the whole structure was sunk half an inch, carrying down with it the remaining eight piles, on which it was brought to a rest uniformly and horizontally, thus permitting the sixteen piles to be abstracted by opening the ground at the back. The whole weight supported by these eight piles was about 910 tons (the weight of the shaft). Having been left for three weeks to dry, and gravel having been heaped under the curb, the remaining eight piles were removed, two by two, till the mass rested on a bed of gravel. The machinery, viz., the thirty-horse high pressure steam engine, with gear for raising the excavated soil was now fixed on the top. The miners were placed inside, and by excavating from around the bottom, the whole descended by its own gravity.

Mr. Beamish then describes the peculiar difficulties which were experienced, previous to the first irruption.

The chasm in the bed of the river, formed by the irruption of 1827, was stopped by bags filled with clay, with hazel rods passed through them, the interstices thus formed being filled with gravel. The irruption of 1828 was met by similar means; but the funds of the company not being then sufficient for proceeding with the work, the shield was blocked up with bricks and cement, and a wall 4 feet in thickness was built within the Tunnel.

The work was then abandoned, and remained untouched for seven years. In 1835 a Treasury loan was granted, subject to the condition, that the most dangerous part of the Tunnel should be executed first. On resuming the works, the first object was to provide a drain for the water from the shield, for which purpose two reservoirs were formed under the middle pier, from which drifts were formed to the bottom of the great excavation and shield. The water was abstracted from the shield at the lowest point, and the pipes of two pumps, worked by the steam engine, being brought into the reservoir, all the difficulty of the drainage was overcome.

The removal of the old and the introduction of the new shield, was a work of no ordinary difficulty. The bricks and cement had, by the strong oxide of iron which the water contained, been converted into a mass harder than most rocks; and not less than 1646 feet of surface, 342 feet of which constituted the ceiling, had to be supported, on the removal of the brick-work, previous to the introduction of the new shield. The means, however, adopted by Mr. Brunel, and which are described in the paper, were perfectly successful.

April 11, 1837.

The PRESIDENT in the Chair.

Thames Tunnel.

Mr. Brunel gave an account of the Thames Tunnel.—Having described the nature and difficulties of the undertaking, and the previous attempts which had been made by others to effect a similar work,* he explained, by reference to sections, the nature of the strata below the river. He had adopted the rectangular form of the present excavation, because the work would set better than if it had been of any other form, and it also had a better sustaining surface. The necessity of supporting the ground, and of having a sufficient shelter, had led to the adoption of the shield, respecting which so much had been said. The construction of this would be most easily understood, by conceiving twelve books set side by side on their ends. These would represent the parallel frames which, standing side by side, but not in immediate contact, filled up the excavation. Each frame was divided into three boxes or cells, placed one above the other, the adjustment of the floors of which, and other details, were minutely described by Mr. Brunel.

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* Vide ante, page 32.

Each frame was furnished with two large slings, by which it might derive support from, or assist in supporting, its neighbours; it had also two legs, and was advanced, as it were, by short steps, having for this purpose an articulation which might be compared to that of the human body. The frame rested on one leg, and then one side was hitched a little forward; then resting on the other leg, the other side was hitched a little, and so on. Hence the shield might be called an ambulating coffer-dam, travelling horizontally.

The brick-work was built in complete rings, and the advantages of this system of building had been fully proved, by the fact of two dreadful irruptions of the river having produced no disruption. Such was the violence of the irruption, that the brick-work had in one part been suddenly reduced in thickness by one-half, and in one place there was a hole, as if pierced by a cannon-ball. At a few feet beneath the tunnel was a bed of quicksand 50 feet deep, and above it were strata of most doubtful consistency, some of which fell to pieces immediately they were disturbed. Still, however, the progress was certain, and only required patience, to allow the ground above to acquire sufficient density. He found gravel, with a mixture of chalk or clay, extremely impervious to water; in some cases he contrived to let out the water from the sand above, and thus obtained ground of sufficient density. The progress had been considerably retarded by land springs, which produced cutaneous eruptions, and destroyed the finger-nails of the workmen.

April 18, 1837.

The PRESIDENT in the Chair.

Thames Tunnel. Mr. Brunel continued his description of the works of the Tunnel. He explained how the ground above had suddenly sunk down, owing to the run of at lower straum of sand. This running sand, which was a great annoyance, consisted of five parts of water to one of sand. Bags of clay and gravel were not so effective, where there were many stones, as the interstices did not become properly filled up; in such cases the coarsest river sand was a better material; the water ran through it at first, but it soon stopped; a mixture of gravel and clay was nearly impervious to water, but not so impervious as gravel and pounded chalk.

The Ventilation of the Tunnel was provided for by a pipe 15 inches square, passing out under the fire-place of the steam-engine boiler.

Mr. Gibbs

Mr. Gibbs stated, that he had found bags filled with clay and tow-waste, exceedingly impervious to water. Being called upon to rebuild a sluice, in a place where piling was impossible, in consequence of the stony nature of the ground, he had formed a coffer-dam, by laying down bags full of clay and tow-waste, in tiers, on the top of each other, up to the surface of the water.

"Description of a proposed Levelling Machine." By John Harrison.

Levelling Machines.

Mr. Harrison proposes to construct a machine, which should describe its own section of the country, as it passes over it. This machine, which in general appearance is like a caravan, on four wheels, is to be drawn by horses; the machinery being moved by the wheels of the carriage. A section is generally made, by marking the lengths on the base line, and the heights on the perpendiculars through these points, and joining the points so marked off. But in this machine, the section is to be described by the continued motion of a point, acted on by two forces, one of which would carry it in a horizontal line, uniformly with the space travelled over by the machine, and the other vertically, according as the machine is rising or falling. The machine is thus divided into two distinct parts, for effecting these purposes, and the way in which this may be practically effected, is described in detail, by reference to an isometrical drawing accompanying the paper.

April 25, 1837.

The PRESIDENT in the Chair.

The paper by Mr. Beamish, which had been commenced at a previous meeting (April 4), was concluded.

Chester Bridge.

Mr. Trubshaw presented to the Institution, a model of the Centre employed by him in the construction of the Bridge over the Dee at Chester.

The peculiar features of this Centre,* consisted in the absence of horizontal timbers, the timbers being so arranged, that their load was received end-ways, and in the laggings being supported over each rib by folding wedges.

Mr. Trubshaw entered into the details of the construction, and method of striking the Centre, explanatory of the account contained in the Transactions.

Projections of Railways.

Mr. Macneill explained a method which he had recently adopted for laying down the sections of Railways, so as to show at one view the position of the cuttings and embankments; and a scale being laid upon the section, their heights and lengths were at once known, in the same way as by measurement on a detached section. This method would be understood, by conceiving the line of railway traced on a map of the country, with coloured parts above, to represent the cuttings, and differently coloured parts below for the embankments.† The outlines of these, would show at once the dimensions of the cuttings and embankments. In engraved plans, the cuttings would be represented by lines, and the embankments by dots, or by stippling. The usual sections would of course be used by engineers, but a section similar to this, would convey at once, all the information requisite for Committees. Two or more lines being projected in this way, the reasons for selecting one in preference to the others would, in many cases, appear at a single glance.

Mr. Macneill proposed also to adopt the terms acclivity and declivity, with a rate marked after them. Starting then from the metropolis, or some principal town, all the ascents would be acclivities, and the descents declivities. Thus all the information generally required, would be conveyed by the inspection of a single section.

May 2, 1837.

The PRESIDENT in the Chair.

The Ordnance Maps of England and Wales were received from the Master-General and Board of Ordnance, and the President announced, that by the munificence of Mrs. Chapman, the Institution was to be made the depository, of all the professional plans and papers, of the late William Chapman, of Newcastle.

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* Vide Trans. Inst. C. E., vol. i. page 207.

† A similar plan is adopted in Stevenson's Bell Rock Lighthouse (Plate III.) to show the depth of the sea and the outline of different sections across the German Ocean.

Mr. Harrison presented a drawing of the Drops erected by him at South Shields, and gave an account of the method of working them.

Maps.

Some remarks were made, on the various methods which had been employed, for representing the nature of a country, as to levels and slopes. In one map of Warsaw, the level of every point was shewn; in the Ordnance maps of France, the heights of most principal points, above the level of the sea, were noted. With respect to slopes, different degrees of shading might be used advantageously for mountain ground, the gentle inclinations being lightly, and the steep places deeply shaded. In some Prussian maps, mountain ground was represented by circular lines at assigned distances; the lines being very near for considerable slopes. One objection to this plan was, that an engraver aimed at a degree of accuracy, which he could rarely arrive at; he could not easily possess sufficient data, to enable him to put the lines, all round a mountain, with any tolerable degree of accuracy.

"On the velocity of the Water in Belfast Harbour." By William Bald, C.E., F.R.S.E., M.R.I.A.

Belfast Harbour.

The Bay of Belfast, or Belfast Lough, is about eleven miles long by three miles broad, and has a depth of water varying from two to eight fathoms at low tide. The bottom consists of mud, and is an excellent holding ground. The mean of thirteen observations, assigns the low water line of spring tides, during the months of January and February last, at 2 feet above the cill of the gate of the new Graving Dock.

The waters of the river Laggan, fed by a basin whose area is 200 square miles, are discharged into Belfast Bay. The average quantity of rain annually being about 36 inches, and assuming that one-third of this falls into the sea by the Laggan river, the quantity will be equal to 1 foot of depth over the whole basin. The mean daily quantity, will be somewhat more than fifteen millions cubic feet. This is the power which, combined with the tidal water, serves to keep open the Channel of Belfast.

On a map, accompanying this paper, are delineated the velocities of the ascending and descending currents, at different states of the tide and parts of the channel.

Locomotive Engines.

Mr. Harrison gave, at the request of the President, some information respecting the fuel and fire-boxes of the locomotive engines on the Stanhope and Tyne Railway. From long experience it was found that coal, which contained much bitumen, caused the tubes of the fire-boxes to leak in a very short time. They obtained coal as free from sulphur as possible, and the consequences had been most advantageous; for during two years and a half, not more than one hundred and twenty tubes had been required for seven engines, of which four were always at work. The tubes were of copper, and $1\frac{5}{8}$ inch in diameter. The usual speed was about 10 miles an hour. One engine weighing 10 tons, on six wheels, conveyed 128 tons of coal. The consumption of fuel was $2\frac{1}{10}$ lb. of coal, per ton of goods, per mile. The gross load was more than double the weight of the goods. The cheapness at which they were able to carry goods was to be attributed to the low speed.

Stone Planing Machine.

Mr. Carnegie, in reply to a question from the President, stated that Hunter's Stone Planing Machine had not originally answered for sharp sandstone; but by endeavouring to imitate the mason's tool, and making the machine work in the same manner as the mason, it had succeeded completely. This tool resembled a comb with short teeth, and curiously enough, he had found at Dresden, a tool which had been in use from time immemorial, exactly similar to that which they had adopted.

May 9, 1837.

The PRESIDENT in the Chair.

"On the application of Steam as a moving Power, considered especially with reference to the reported duties of the Cornish and other Engines." By G. H. Palmer, M. Inst. C. E.*

Steam as a moving power.

In this paper, Mr. Palmer first considers the maximum duty which can be done by atmospheric steam, and then, by reasoning analogically from certain theories, some of which are recognised as established, he infers that highly elastic steam, worked expansively, cannot be as economical as atmospheric steam. The reasoning by which the first question, namely, the amount of duty done, is treated, is as follows: One bushel of coal, weighing 84 lbs., will convert 12 cubic feet of water into atmospheric steam, or each cubic foot of water is made to occupy 20,328 cubic feet. This may be applied directly to raise a column of water, say 35 feet high; that is, 84 lbs. of coal will, in the absence of all friction, be effective for raising 20,328 cubic feet of water 35 feet high; that is, 1,270,500 lbs. 35 feet high, or 44,573,375 lbs. one foot high. Making then the usual deduction of four-tenths for friction, according to Tredgold's calculations, we have about 26,000,000 lbs. as the effective duty of the atmospheric steam produced by 84 lbs. of coal.

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* Vide Trans. Inst. C. E., vol. ii., page 33.

Mr. Palmer, having thus ascertained the maximum duty of 84 lbs. of coal, proceeds to infer that high pressure steam, worked expansively, must be less efficient than this; and the reasoning, by which he arrives at this conclusion, is founded on the following theories :—

1st. That the sum of the latent and sensible heat is a constant quantity.

2nd. That all matter, steam of course included, evolves caloric on compression, and absorbs caloric on dilation.

3rd. That equal quantities of water will always require equal quantities of fuel, to convert it into atmospheric steam; but though equal weights of water, must absorb equal increments of caloric, when atmospheric steam is generated, it does not follow, that all the caloric absorbed in high pressure steam, is exclusively supplied by the fuel expended.

4th. That steam, of the elasticity of two, or more atmospheres, does not contain two, or more times the quantity of water, contained in atmospheric steam; but contains proportionably less water, as the pressure under which it is generated is increased.

The preceding principles are illustrated, explained, and insisted on in great detail, and the author infers from them, that the high pressure steam generated by one bushel of coal cannot, when worked expansively, perform more duty than atmospheric steam, unless, as is premised in the earlier part of the paper, more than 62½ lbs. of water can be converted by 7 lbs. of coal, from 40° Fahrenheit to atmospheric steam, and unless steam can dilate without converting sensible into latent caloric.

May 23, 1837.

The PRESIDENT in the Chair.

Duty of Engines.

The paper by Mr. G. H. Palmer, commenced at the last meeting, having been concluded, a discussion ensued on the duties of Engines. The question was asked, whether the water raised had been actually measured, and whether the calculations were not made from the known contents of the working barrel. It was the general opinion, that the duties had always been ascertained in the latter manner. An engine on the Cornish system, erected near London, was stated to have done a duty of fifty millions, and the Cornish system of clothing was considered, as effecting a very considerable saving in the fuel.

"Account of some Blasting Operations through the white Limestone on the Antrim Coast Road, in the north of Ireland." By William Bald, C.E., F.R.S.E., M.R.I.A.

Blasting Rocks.

In the commencement of the paper, the nature of the Antrim Coast and of the white limestone, and the method of blasting, are briefly described. This limestone is somewhat similar to the chalk of England, flints being found in it, but it is exceedingly indurated. From the results of the blasting of several large masses of rock it appears, that 1 oz. of powder will rend 14·12 cubic feet of this limestone, when in blocks; whereas the same quantity of powder is required, for 11·75 cubic feet of loose whinstone blocks. The specific gravity of the white limestone is very nearly 2·760, and of whinstone, or basalt about 3·200. The induration of white limestone may be estimated from the fact, that two men will bore 1 foot deep in half an hour, the diameter of the augers, or jumpers, being from 1$\frac{5}{8}$ths to 2 inches.

A table is given, exhibiting the diameter of the auger or jumper used, and the number of inches of gunpowder put in—1 lb. of gunpowder occupying 30 cubic inches. The force of the explosion of gunpowder, is assumed to be, as the cube of the line of least resistance; if 1 oz. of gunpowder will open a distance of 1 foot of rock, 2 feet would require 8 oz., and 10 feet 1000 oz. There will be some difficulty, in ascertaining the line of least resistance in stratified rocks, since the rock may be fissured, or some bed or opening may lie near to the line bored; but the hypogene rocks, as granite and sienite, lying in compact unstratified masses, present no such difficulty.

The paper is accompanied by drawings and sections, showing the mode pursued in blasting down high cliffs, by boring at the toe of the rock; the peculiar character of the veins, commonly called skull veins, from their strong resemblance to the sutures of the skull, which traverse the blocks of white limestone; and concludes by expressing the importance, of collecting accounts of the quantity of gunpowder consumed per cubic yard, in blasting the various kinds of granite, sandstone, &c.; also the diameter of the augers, or jumpers; the depths bored, and the quantity of gunpowder proved to be most effective.

May 30, 1837.

The PRESIDENT in the Chair.

"On the results obtained by Mr. G. H. Palmer, respecting the Maximum Duty of a given quantity of Atmospheric Steam." By Thomas Webster, M.A.; Sec. Inst. C. E.

Duty of Engines.

The object of this paper is to show that the result obtained by Mr. Palmer, in his paper on Steam, read at the two previous meetings of the Institution,* coincides very accurately with the authenticated accounts of the best Boulton-and-Watt engines. In the calculation made by Mr. Palmer, no account is taken of the heat rescued by employing over again the hot water. This, considering the relative quantities of latent and sensible caloric in steam, may be taken at one-sixth; and being taken into the account, we may consider, that, on the principles laid down by Mr. Palmer, the duty done by a Boulton-and-Watt engine ought to be about thirty-two millions.

The next question is, what amount of saving is to be attributed to the system of clothing, adopted in the Cornish engines. This, it is stated, may change the data entirely; the quantity of water evaporated may be very different and the quantity of heat saved and worked over again incalculable; at present then, no principles of theoretical calculation can be applied to this case.

"Further observations on Blasting the white limestone of the Antrim Coast." By William Bald, C.E., F.R.S.E., M.R.I.A.

Blasting Rocks.

These further observations are directed more especially, to the principle assumed by Mr. Bald in his previous communication, that the force of the explosion of gunpowder, is as the cube of the length of the line of least resistance. This is the law, which Vauban and Belidor have been led to assume, as the result of their investigations, and Mr. Bald proceeds to show, that his experiments confirm it. It appears from the experiments there detailed, that 1·9 oz. was required for the smaller blocks, and 2 oz. for the larger, per cubic yard. Knowing then the quantity of gunpowder used, and the solid contents of the blocks, by extracting the cube root of the cubical contents, their respective masses are shown in a cubical form. Taking then, the length of the line of least resistance in each of these cubes, to be equal to the distance from the centre to the nearest point on the surface, the preceding calculation gives the lengths of these lines; and it appears, that these experiments confirm the law of the explosive power of gunpowder, being as the cube of the line of least resistance.

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* Vide ante, page 38.

The paper concludes, with remarks on the purposes for which this limestone is adapted, and on the ravages, to which all calcareous rocks are subject from the *Pholas dactylus*, and is illustrated by drawings of the forms of the fissures of the limestone, and of the beautifully radiated and fluted shell of the *Pholas*. From the natural curves in this shell, the engineer may learn the best shape, to be given to the slopes of breakwaters and harbours, exposed to the run of the ocean.

"On Warming and Ventilating." By James Horne, F.R.S.; Assoc. Inst. C.E.

Warming and Ventilating.

In this paper, the author describes a method of warming and ventilating, on the principle of spontaneous ventilation, by means of an iron stove; care being taken that the quality of the air is not affected, by the iron plates exceeding a certain temperature; he also mentions a successful attempt, to warm and ventilate a chapel on the same plan.

Mr. Horne gives also, an account of a method, which he had adopted, to ventilate an extensive drift, or level, by forcing in air. The machine, a drawing of which, with all the details and dimensions, is annexed, consists of an upper cylinder inverted, and working in a lower cylinder nearly full of water. An attempt was at first made to ventilate by drawing out the foul air; this, however, did not succeed. The level was 7 feet high, and 4 feet 6 inches wide, and was driven a mile, before it rose into an upper level; the rise was then put up 400 feet in height; both the level and the rise were ventilated successfully by this apparatus. The diameter of the ventilating pipe was 5 inches, and its length a mile. This showed most satisfactorily, that ventilation could be effected, by forcing in air through a great length of pipe.

Some conversation took place, on the power expended in producing this ventilation, and on the friction of air forced through pipes. Reference was made to several cases, which seemed to show, that air could not be forced with effect through a great length of pipe, for the purpose of blowing blast furnaces, whereas some experiments seemed to show, that air could be forced through small pipes of 50, 100, or 150 feet, in length, with the same velocity under a given pressure. **Friction of Air in Pipes.**

Mr. G. H. Palmer stated, that if 100 cubic feet of air could be forced through a small hole, under a pressure of 1 inch of water, in a given time, only 25 cubic feet would be delivered under the same pressure, through a pipe 1000 feet in length in the same time. **Mr. G. H. Palmer.**

Mr. Hawkins stated, that in the old Thames Tunnel, a pipe of 2 inches diameter had been found quite insufficient for ventilation, at a distance of 400 feet; but that a tube 3 inches in diameter from the same bellows, and under the same pressure, had been quite sufficient. In the former case it was suggested, that the friction of the pipe was nearly the same as the pressure in the bellows, so that the air was simply condensed. **Mr. Hawkins.**

Several other instances and experiments were quoted, and it appeared, that it must often be considered whether the condensation had time to take effect. The air might be condensed rapidly, and none forced out; but if the operation took place slowly, the condensation would have time to take effect.

June 6, 1837.

The PRESIDENT in the Chair.

The subject of forcing air through pipes and ventilation being resumed, Mr. Cottam stated a case in which a circular blowing machine, having a straight pipe 10 feet in length and 6 inches in diameter, was sufficient to supply three furnaces; but that a single elbow rendered it incapable of supplying one. **Ventilation. Mr. Cottam.**

Mr. Oldham, of the Bank of England, stated, that in all the attempts which he had made to effect any purpose, he always endeavoured to imitate nature. Now nature supplied a large quantity of air slowly heated. He had consequently established a stove with a very large heating surface, and a pump capable of delivering 50 cubic feet of air per stroke. To get rid of the foul air, he made large openings in the roof, and took care that there should be an abundant supply of air properly heated. The air was brought in at a temperature of **Mr. Oldham.**

180° F.; thus there was a rapid change of air; and a summer heat was obtained, without any sense of oppression. The success which had attended this system during two frightful seasons of typhus and cholera in Dublin, could be attested by many medical men. In the middle of winter he kept the doors and windows open, and threw an abundance of warm air into the wards of a hospital so heated and ventilated.

"On the methods of Illuminating Lighthouses, and on a Reciprocating Light." By Captain Smith, Madras Engineers, F.R.S.; Assoc. Inst. C. E.*

Lighthouses.

In this paper, Captain Smith details the two different systems of fixed and revolving lights, which are generally adopted, and the objections to which each is liable. In the fixed light, the effect produced is precisely proportioned to the means employed, and none of the light is lost, since none of the reflectors are pointed inland; but in a revolving light, provided the revolution continues complete, part of the light is expended to no purpose. The revolving light is however necessary in many cases, since it is only by a series of flashes and eclipses, succeeding in a determined order, that the particular lights on a thickly-studded coast can be distinguished from each other.

As a means of obviating the objections to which each is liable, Captain Smith proposes, in places where lighthouses are not numerous, to stop the revolution of the apparatus, after a certain portion of the circumference has been traversed, and then to reverse the motion so as to cause the light to reciprocate. The action of the reflectors is thus confined to the sea-side only. By this means a light may be obtained at five-eighths of the expense usually incurred.

The paper is accompanied by a diagram, descriptive of the mechanical contrivance for obtaining this alternating motion.

June 13, 1837.

The PRESIDENT in the Chair.

Ventilation.

Mr. Oldham resumed the account of his system of warming and ventilating, and exhibited a model of his stove for heating the air. He was convinced that the expedient of forcing the air by mechanical means must be resorted to. He had raised the temperature of a room 24° F. in one hour, whilst by spontaneous ventilation he could never obtain a temperature of more than 100° F., but by pumping in the warm air he readily obtained a temperature of 150° F., or 180° F.

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* Vide Trans. Inst. C. E., vol. ii. page 193.

Lamp for Light-houses, &c.

Mr. Horne directed the attention of the Institution to a lamp, which he thought was peculiarly applicable to lighthouses, or wherever an intense light was required. The usual burners were an inch in diameter; he had, however, succeeded in producing a clear white light by a burner of half an inch in diameter. The excellence of the light was due to the complete combustion, obtained by making the area of the external, equal to the area of the internal apertures. The air thus passed directly to the burner, and there was a perfect uniformity of draught which might be regulated, by the height at which the burner was placed above the bottom of the glass, or chimney. The draught of air being thus supplied with perfect equality to both sides of the wick, a flat and steady flame of two inches in height was obtained, and the force of the draught was sufficient to prevent the flame from touching the edge of the burner, so that the edge was always clean and fit for use.

"A series of Experiments on the Elastic Weight and Strength of Cast Iron Beams." By Francis Bramah, M. Inst. C.E.*

Strength of Iron.

This very extensive series of experiments, had been undertaken several years ago, with the view of verifying the truth of the theory of Bernouilli, Young, and Tredgold, with respect to the equality of the forces of extension and compression in cast iron, within the elastic limit. The experiments are accompanied with a paper, fully explaining the method in which they were conducted, and with a drawing of the proving machine.

"A practical Method of forming the Stones of an Elliptic Arch." By William Bald, C.E., F.R.S.E., M.R.I A.

Voussoirs of Elliptic Arches.

In presenting this paper to the Institution, the author has no object in view; but to leave a record of the proceedings of an operation, successfully carried into execution more than seventeen years ago. This consists in the application of the well-known property of the elliptic, "that the lines from the foci make equal angles with the tangent at any point." The moulds are thus traced out, by drawing a few straight lines.

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* Vide Trans. Inst. C. E., vol. ii., page 113.

This plan was adopted in the construction of a bridge over the Owen-More river, in the west of Ireland; and a model of the two courses of the cutwaters of this bridge was presented to the Institution. In these courses, the stones were cut so as to break joint with each other, and the blocks were connected together into one course, after the manner so ingeniously devised in the construction of the Edystone lighthouse.

The meeting of the Institution was then adjourned to the second Tuesday in January, 1838.

The Council wish to call attention to the following subjects for Original Communications, and for Premiums, during the ensuing Session.

1. The Nature and Properties of Steam, considered with reference to its application as a moving power for Machinery.
2. The warming and ventilating Public Buildings and Apartments; with an account of the methods which have been employed most successfully, for ensuring a healthy state of the atmosphere.
3. An Account and Drawings of the original construction and present state of the Plymouth Breakwater.
4. The ratio, from actual experiment, of the Velocity, Load, and Power of Locomotive Engines on Railways. 1st. Upon Levels. 2nd. Upon Inclined Planes.
5. Drawings, Description, and Account of the Principles of Huddart's Rope Machinery at Limehouse.
6. The Sewerage of Westminster.
7. Drawings and Description of the Shield at the Thames Tunnel, with an accurate Account of the method by which it is advanced and worked.

In the distribution of the Premiums, no distinction will be made betwixt the communications of Members, Associates, and others in no way connected with the Institution, whether Natives, or Foreigners.

The Council will not consider themselves bound to award any Premiums, should the communication not be of adequate merit; but the Council will award valuable Premiums to communications of distinguished merit, or more than one Premium, should there be several communications on the same subject deserving this mark of distinction.

The communications must be forwarded to the house of the Institution, 1, Cannon Row, Westminster, on or before the 31st March, 1838.

In pointing out the above subjects, the Council wish it to be understood, that it is not intended to confine the Premiums of the Institution to Memoirs and Drawings on the above subjects; but that all communications of distinguished merit will be rewarded. The Council publish these, in the hope of directing attention to subjects of great general interest, and with the view of pointing out the kind of communications which they are anxious to reward. The Council trust, that those who have possession of drawings and details of works similar to those just mentioned, will feel the importance of leaving to posterity, some public record of the execution and present state of the works, and afford those who are disposed to prepare these records, every facility of access to such documents.

THOMAS WEBSTER, *Secretary*.

1, *Cannon Row*, *Westminster*,
July 1, 1837.

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The Institution is not, as a body, responsible for the facts and opinions advanced in the following abstracts of the papers read, and of the conversations which took place at the Meetings of the last Session.

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SESSION 1838.

ANNUAL REPORT.

Annual Report.

THE COUNCIL, to whom has been confided during the last year the management of the affairs of the Institution, being called upon, at the return of this the Annual General Meeting, to resign their trust, and to report on the state of the Institution, solicit the attention of this meeting to the following Report on their proceedings, and on the state and prospects of the Institution at the close of the nineteenth year of its existence. And in the commencement of this report the Council cannot omit to express their satisfaction at the manner in which their efforts have been responded to by the general body, and it is peculiarly gratifying to them to be able to present a report which they believe will not be inferior in interest to that which has been presented on any previous occasion.

During the past year the attention of the Council has been directed to many important alterations, not only in the ordinary business of the Institution, and in the introduction of such measures as may tend to the convenience of the general body, but also to changes affecting the constitution and permanent stability of the Institution itself. It is known to most here present, that since the close of last session the Bye-Laws then in force have been abrogated, and a fresh code enacted.

Mr. Farey's La

Many here present are aware, that certain propositions were three years ago submitted by Mr. Farey to a General Meeting of Members, and adopted unanimously. In conformity with the spirit of these resolutions, Mr. Farey, at the request of the Council and of the late President, subsequently drew up a very elaborate set of Bye-Laws and Regulations, which were, by a General Meeting of Members, referred to the Council for their examination and report. The detail into which a desire to provide for any possible contingency, and to present a code of laws by which the body might be guided both in its infancy and maturer years, had led this distinguished Member of your Institution, rendered this a most difficult task for the Council to perform, and the many important alterations therein suggested continued for a time in abeyance.

The attention of the Council has, however, been continually recalled to them, as well by the approbation which these resolutions of the General Meeting of Members met with from all classes, as from the increasing number of applicants for admission, and the growing importance of the Institution; and the Council resolved to recommend a new set of Bye-Laws and Regulations. These, with some few alterations, were adopted by a General Meeting of Members, held on the 26th of last December, and are now, in conjunction with the charter, the Laws of the Institution.

Revision of the Bye-Laws.

The main objects which the Council had in view in the revision of the Bye-Laws, were to render them consistent with the provisions of the Charter, and with the language therein employed; to give a more decided character of organization to the Institution by a better classification of the individuals composing it, and to render the qualification of the classes more distinct, definite, and consistent with the general objects of the Institution. If the Council have failed in accomplishing these important objects, they feel that it must be attributed to the difficulty of the task, and not to the want of mature deliberation. The useless and merely nominal distinction betwixt Members and Corresponding Members has been removed; their qualifications being identical, the existence of this nominal distinction and of two classes could not fail of being attended with disadvantages, and has been misunderstood as implying a distinction which was never contemplated.

These two classes are, by a Special Resolution of the General meeting of members, to be incorporated in one class in alphabetical order.

The qualifications also for admission into the class of Associates were very ill defined; the whole rising generation of Engineers, or future Members, being included in this class, it was thereby rendered devoid of the distinct character which it ought to possess.

Graduates.

The creation of a new class under the term Graduates, as suggested by Mr. Farey, will, it is expected, afford the means of that classification which was so much to be desired. In this class will be enrolled those who, either as pupils or assistants to Engineers, are qualifying themselves for the practice of the profession, and are attaining to that degree of experience and knowledge which, in the opinion of at least ten of the general body, with the concurrence of the Council, will entitle them to be enrolled in the class of Members.

Associates.

The class of Associates will, it is expected, in future consist of men of experience in pursuits connected with the practice and profession of the Civil Engineer. By the assistance and co-operation of this class, the bounds of knowledge in the infinite variety of subjects which come under the attention of the Engineer may be extended, and thus that which the talents and resources of one could not attain may be readily attained by the co-operation of many engaged in similar pursuits.

Honorary Members.

The existence of a class of Honorary Members, consisting of eminent Engineers of foreign countries, and of others illustrious for their attainments in science, and experience in matters connected with the profession of the Engineer, enables the Institution to connect itself with the names of those of every country who shed a lustre on the profession, or on science in general.

Objects of the Institution.

Thus it is conceived that the Institution has been more adapted to the wants of the present generation; and as it was the wants of society which first called it into existence, so may it reasonably be expected that the continuance of those wants will keep it in a state of progressive improvement and adaptation. The nature of these wants, and the means by which they were in a great measure to be relieved, are, in the address of your Vice-President, Mr. Palmer, to the meeting which called this Institution into existence, set forth in the following manner:

"It is a remarkable fact that, notwithstanding the extensive advancement of science and the general increase of means for an acquaintance with it, that while the principles of systematic education for most of the learned and scientific professions have been and still are actively encouraged, not even an attempt seems to have been made towards the formation of any special source of information or instruction for persons following or intending to follow the important profession of a Civil Engineer; in the practice of which the utmost skill of man is called forth, and which requires not only a knowledge of one leading branch of science, but many—not only of one leading art, but of an indefinite number. For the Engineer, being a mediator betwixt the Philosopher and the working Mechanic, must, like an interpreter betwixt two foreigners, understand the language of both. If then we consider for a moment the continued application necessary to familiarize us with any one branch of art or science, surely any argument to enforce a persuasion of the utility of an Institution to facilitate the qualification for a profession in which many branches of both art and science are necessary, must be superfluous."* By such feelings were your Vice-President and first Members* then actuated in forming the Institution; and that these wants, then so urgently felt, have been in some measure supplied, no one can doubt who looks to the continued progress and present state of the Institution. The attainment, in some measure, of the objects proposed, has kept the Institution in a state of progressive improvement up to the present time, and the continued co-operation of all classes cannot fail of producing similar good effects in time to come. For by the opportunities here afforded the more experienced in the profession may extend their knowledge by communicating with others equally experienced; the rising generation of Engineers may communicate with each other, and receive instruction from the oracles of the profession, and acquire knowledge which conversation alone can give. Here, also, in the records of the Institution, all may become acquainted with the opinions and the practice of the past and the present, and possess opportunities of consulting works and documents to be found in no other place. And when to these advantages are added that of meeting with men of eminence in collateral pursuits, as Associates and Honorary Members, the Council do conceive that the spirit in which the Institution was projected has been well followed out, and its good effects in some measure realized; and that the experienced Engineer, no less than the Student in the profession, possesses opportunities for which, twenty years ago, he would have sought in vain.

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* See *Address*, by H. R. Palmer, Jan. 2, 1818; *Minutes of Session*, 1818.

Much has at times been said respecting the establishment of a School of Engineers, and many comparisons have been drawn betwixt the advantages possessed by this and other countries in this respect; but not for an instant to enter on the great question of the nature of a complete establishment under that name, it may with confidence be asserted that this Institution is in itself a School of Engineers; a school, not in the sense of the term where knowledge is forced upon the unwilling student, but one where the attentive student possesses remarkable opportunities for self-improvement by study and mutual intercourse.

Increase of Subscriptions.

Thus much have the Council thought it right to state respecting the principles by which they were guided in changing the classes composing the Institution; they now proceed to make a few observations on some other changes—and, first, with respect to the alteration in the admission fee and annual subscription. Those who now join the Institution enter at once upon so many advantages which their predecessors did not possess, that an increased contribution may most reasonably be required of them. Such increase is however confined entirely to the class of Members and Associates. Those who join the Institution as Graduates will pay no admission fee until transferred to the class of Members, and their annual subscriptions are as low as seemed compatible with securing sufficient funds for the wants of the Institution. For it being conceived that those enrolled in this class will in general be young men, assistants to Engineers and not holding lucrative situations, or pupils in the office of an Engineer, and not yet engaged in practice, it seemed consistent that such should be relieved as much as possible from the weight of the annual subscriptions.

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* Messrs. William Maudslay, Henry R. Palmer, Joshua Field, James Jones, Charles Collinge, and James Ashwell.

The Members, on the contrary, being generally engaged in active practice, and moreover the governing body under the Charter, it seemed right that the increase in the subscriptions should fall principally upon them; and, from the same considerations, the Council are called upon to contribute in a still larger amount. But since cases will arise in which, from various causes, the annual subscription may be necessarily but unwillingly withheld, there is by the Charter wisely reserved to the Council the power of providing against such contingencies, and continuing to the individual his full rights and privileges—and the Council will never permit an Institution which exists for mutual benefit to become oppressive to any one of the individuals who compose it.

The exigencies of the Institution imperatively demanded such an increase in the annual subscriptions. The present premises are too well known to be perfectly inadequate to the wants of the Institution, and all applications to the Government having been unavailing, the Council have taken premises in Great George Street, which are from their extent extremely well suited to the purposes of the Institution, and sufficient for its accommodation for years to come—from their contiguity also to the Houses of Parliament, extremely conveniently situated for those non-residents who are brought annually to town on parliamentary business. In these premises there will be a spacious and lofty meeting room, a model room, a gallery forty feet long, a library, and Council room, and many other rooms admirably adapted for reading rooms, and private meeting rooms for the convenience of the general body.

Independently, however, of the necessity of providing more spacious premises, it has become of paramount importance that the general body should, by the publication of Transactions, Minutes of Proceedings, and the issuing of weekly notices, be regularly made acquainted with what has occupied, or continues to occupy, the attention of the meetings; since it is by these means that the Institution is to be carried on with energy and efficiency, as well as by furnishing every facility for consulting the documents, and every reasonable convenience and comfort for the accommodation of those who frequent the house, of the Institution. The Council trust that their efforts to advance the Institution will be responded to by the general body, and that those funds which may be required for establishing and maintaining the Institution in a manner worthy of the name and character of the profession will not be withheld.

In making, however, this urgent call for increased funds, the Council cannot omit to advert briefly to a misconception which has arisen in the minds of some, as to whether the new enactments respecting the subscriptions are to be imperative on the existing body. That it is extremely desirable, for the advance of the Institution, that each one should consider them, so far as may lie in his power, as imperative, no one can doubt; but in this, as in all other cases, it was never the intention of the Council to bring forward or to enforce any regulations which should not be cordially responded to by the general body. That the class of Members did cordially assent to these enactments respecting the increased subscriptions may be most reasonably inferred, since the Bye-Laws relating to them passed without any discussion, and without a single dissentient voice. But inasmuch as there are many who, owing to the peculiar constitution of the Institution, had no opportunity of publicly expressing their opinion on these enactments, and who, having been for some time contributors, may consider that the call to assist in advancing the Institution by this necessary addition to its funds ought not to be made upon them, the Council take this opportunity of stating, that it was never the intention to consider such addition as compulsory on the existing body, or that, on its being withheld, they as the executive should be called upon to erase the name of the individual from the register of the Institution. The Council are aware that this statement may appear unnecessary on the present occasion; but they would beg any one who may have been actuated by these or similar feelings to consider, whether the prospect which lies before the Institution of becoming permanently useful, does not call upon each one to exert himself in every way for its advancement.

Constitution of the Council.

An alteration has also been made in the constitution of the Council. This has hitherto been composed entirely of Members; it has been thought advisable that the general body should have the power of adding two Associates; that as the Institution is considerably indebted to their active co-operation, the Council also should not be deprived of the valuable assistance of some of the distinguished individuals enrolled in that class. They recommend therefore to the

Meeting that two Associates should be added to the Council. On the other alterations tending to give greater efficiency to the Institution the Council cannot now dwell, but conclude their remarks on this subject in the words of the late President, who, on accepting the proffered chair of the infant Institution, and having expressed his approbation of the laws then enacted, observed, "judicious regulations are absolutely necessary in all societies, but I trust that in this the good sense of the members will always feel that manners and moral feeling are superior to written laws."

Catalogues.

The Council will now proceed to advert to the other events of the past year, and they have great satisfaction in being able to report that considerable progress has been made towards arranging the many valuable documents in the possession of the Institution. A Catalogue of the Library has been printed, and the greater part of the books and pamphlets have been bound, and so arranged as to be readily referred to by means of an interleaved Catalogue, in which the place of each work is distinctly registered. Catalogues have also been made of the Original Communications, and of the Telford Plans, and cases provided for the latter so as to be conveniently consulted. The complete arrangement of the invaluable manuscript documents of the Telford Bequest is a task of no ordinary difficulty, but one to the speedy completion of which the attention of the future Council should be especially directed.

Minutes of Proceedings.

The attention of the Council has been directed to the publication of an Abstract of the papers read, and of the conversations which take place; and such an Abstract, under the title of Minutes of Proceedings, was published soon after the close of last session; and it is the wish of the Council that these should appear at regular and short intervals during the session, while the subjects discussed and alluded to are still fresh in the recollection. On the advantages of this plan it is almost unnecessary to insist, since it has been adopted and approved by many eminent Societies. The public is thus brought immediately into contact with the Institution; the labours and opinions of the author are made known and canvassed while the subject is yet warm with interest, and attention is continually kept alive to the state and progress of each department of knowledge. An authentic and public record also is thus opened, and the credit due to authors for priority of invention and discovery is secured as matter of history. Add to which, there are communications of transient interest, but which could not be deferred to the publication of the Transactions. It is conceived that the Minutes of Proceedings will furnish a record of papers, remarks, and events, of partial or transient interest, which would be comparatively of little value unless published at the time;

and that the Transactions is the channel through which all more elaborate communications of universal and lasting interest are to be brought before the world.

Transactions.

The attention of the Council has also been directed to the publication of another volume of the Transactions; several communications have been selected, and the work is in so forward a state, that the Institution may confidently expect the publication of the second volume before the close of the present session.

Telford Medals.

The Council have also to congratulate the Institution on the completion of the Telford Prize Medals. This beautiful specimen of Mr. Wyon's skill, with the head of Telford on the obverse, and the Menai Bridge on the reverse, was completed last year, and at a public dinner of the Institution on the 3d of last June, the following medals were presented:

A Gold Medal to John Timperley, for his MS. account of the Hull Docks.

A Silver Medal to each of the following—

- To John Macneill, Member, for his Canal Boat experiments.
- To James M. Rendel, Member, for his account of the Lary Bridge.
- To Michael A. Borthwick, Associate, for his account of Iron Piling.
- To Benedetto Albano, Associate, for his account of the bridge at Turin.
- To Peter Barlow, Jun. for his paper on Lock Gates.

The communications for which these were adjudged are recorded in the first volume of the Transactions of the Institution.

Several important subjects have been published for Prizes during the ensuing session, and the Council have every reason to expect many valuable communications on these subjects, and they would also take this opportunity of reminding those who may be preparing communications on any of these subjects, that they are to be sent in on or before the 31st of next March.

Proceedings of last Session.

On the proceedings of last session it is unnecessary to make any other remark than that they exceeded in interest those of any preceding session, both in the variety of the subjects embraced, and in the interest excited. The Minutes of Proceedings already alluded to will furnish a brief account of all the communications which were made, and the discussions to which they gave rise.

Presents.

The Presents, during the last year, have been exceedingly numerous and valuable, and the Council would take this opportunity of acknowledging their obligations to the Lords of the Admiralty, to Captain

Beaufort, and to Lieutenant Beecher, for the Admiralty Charts; to the Lord Lieutenant of Ireland and Colonel Colly, for several of the Ordnance Maps of Ireland; and to your President, for the volumes of the Philosophical Transactions, which complete the set of 123 volumes from the commencement, presented by him to the Institution. The other presents, which are far too numerous to be here mentioned, will be recorded in a list accompanying this report.

The following abstract of the receipts and expenditure during the year ending the 31st of December, 1837, will shew the present state of the funds of the Institution:

Cash Account.

Dr.							*Cr.*
To Balance in hand, Jan. 1.	111	4	3	By Library	110	3	2
— Fees and Subscriptions	531	8	0	— Furniture	16	14	6
— Dividends	74	8	10	— Publication	28	8	6
				— Short Hand Writer	51	16	8
				— Coals and Candles	27	18	11
				— Stationery & Engraving	27	13	4
				— Petty Cash	33	2	10
				— Rent, Taxes, & Repairs	92	10	6
				— Salaries & Commission	301	11	3
				— Balance	27	1	5
	£717	1	1		£717	1	1

Arthur Woolfe.

The Council have to regret the loss to the Institution by death of its Member, Arthur Woolf. This distinguished individual was born at Camborne, in Cornwall. He was a millwright, and in that capacity went to London, and was employed in Meux's Brewery. In 1804, he took out a patent for his Two Cylinder Engine, working high pressure steam in a small cylinder, and allowing it to expand in a large one. When he first commenced erecting engines in Cornwall, he induced the proprietors of the Foundries to improve their machinery, that a better style of workmanship might be used in the manufacture of steam engines; and he introduced an improved Hornblower's double beat valve. The work done at the Consolidated Mines, proves him to have been a person of great talents. In October, 1814, the average duty of the engines in Cornwall was 20½ millions—Woolf's engine at Wheal Abraham, however, performed 34 millions—and in December 1815, 52 millions; and in May 1816, 57 millions; while the average duty of all the engines reported in Cornwall was 23 millions. In 1820, Mr. Woolf erected engines at the Consolidated Mines having cylinders of 90 inches in diameter, and a stroke of 10 feet—the most powerful that had ever been constructed. In December, 1827, a trial took place with one of Woolf's 90-inch engines, and it performed a duty of 63½ millions—the average duty of 47 engines reported in this year was 32 millions. For some years before his death he received a pension of £100. a year from the proprietors of the Consolidated Mines. His name is associated with the improvements in the drainage of the Cornish mines; and whatever share posterity may assign to his individual genius in these improvements, his name is recorded in the page of history among those who have dedicated their talents and the opportunities of a long life to the advancement of practical science.

Subjects for Discussion.

The Council have also endeavoured to make arrangement for a supply of original communications for the present session. With this view they, in addition to the notice of Prize subjects already mentioned, have issued a list of subjects for discussion which were brought before the Institution during the last session, and requested such information upon them as parties might be able to communicate.

On several of these, important information has been received. The Council have also received promises of many communications at an early period, so that they look forward with confidence to the present session being equal in importance to any which has preceded it.

Conclusion.

Confident in this belief, they resign with the greatest satisfaction the trust which has been confided to them. Their efforts during the past year to render the Institution more efficient and useful, have been amply rewarded in the success which has attended them; and they trust that, in every succeeding year, the Institution will more and more fully realize the hopes of its most sanguine supporters, and ere long be recognised by all as conferring an honour no less on the British Nation than on every one of those by whose superintendance it is continually adapted to the wants of each successive generation.

ORIGINAL COMMUNICATIONS.

Bald, Wm. On the velocity of water in Belfast Harbour.

——— Account of some Blasting operations through White Limestone, on a part of the Antrim Coast Road.

——— Further observations on the same.

——— Account of the Vouissoirs of the four elliptic Arches in the Bridge erecting over the Owenmore River in the West of Ireland.

Ballard, Stephen. On a method of breaking Ice by forcing it upwards.

Beamish, R. On the Thames Tunnel.

Bramah, Francis. Series of Experiments on Cast Iron.

Bray, W. B. On the strength of Iron Girders.

Bull, Wm. Description of a Bridge over the Calder.

Denison, Lieut. On the strength of Timber.

Edwards, Geo. A Steam Expansion Table, with Description.

Guy, Henry. Description of a method of producing true Spherical Balls.

Harrison, J. On a new Levelling Machine.

———, T. E. Account of the Drops at South Shields.

Hays, W. B. Description of a River Cleaning Machine.

Horne, James. On the strength of Timber.

——— On Warming and Ventilating.

——— Remarks on some of the Suspension Bridges on the Continent.

Jones, J. Account of the Youghal Bridge.

Koehler, Herman. On Railways.

Marsh, W. Description of his method of making true Spherical Balls.

Mitchell, A. Description of a new Boring Apparatus.

Palmer, G. H. On Steam as a Moving Power, and on the amount of Duty.

Perkins, J. On Locomotive Engines, and the means of supplying them.

Reynolds, J. On the Construction of Railways of continuous Bearing.

Robertson, H. Description of a new Lewis.

Smith, Captain I. T. On a Reciprocating Light for Lighthouses.

Sykes, Wm. On the Wheels of Locomotives.

Webster, T. On experiments on the strength of Materials.

——— On Mr. Hodgkinson's experiments on the strength of Cast Iron.

——— On Mr. G. H. Palmer's Paper on Steam.

CATALOGUE OF PRESENTS.

BOOKS.

TITLE OF BOOK	DONORS
Abbatt, R. on the Calculus of Variations .	Mr. Horne.
Abbott, Geo. Jun. on the Mines of England .	The Author.
——————— the same, a Tract . .	
Abhandlung uber die Cohasions, and Elastitats	Herrn Wedding.
————————————	Herr Beuth.
Abhandlungen der Koniglichen Technischen Deputation fur Gewerbe	Herr Beuth.
Act for continuing Turnpike Acts near expiring	Mr. Dike.
—— to confer certain Powers on Trading and other Companies	
—— relative to Arbitration of Disputes between Masters and Workmen	
—— for Management of Post Office . .	
—— for Promotion of Public Works in Ireland	
Admiralty Charts	The Admiralty.
American Almanack, 1837	Professor Henry.
Annales des Pontes et Chaussees, 25 parts, Continuation, 5 parts	Mr. Macneill.
Annuaire, pour l'An 1837	Mr. Bald.
Architectural Magazine	The Editor.
Bald, Wm. Report on the Harbour of Drogheda	The Author.
Barlow, P. Mathematical Dictionary . .	Mr. Hallen.
————— on the Strength of Materials and Construction	Mr. Weale.
Barretti, J. Italian and English Dictionary, 2 vols.	Mr. William Cubitt.
Bauansfuhrungen des Preussischen Staats, 3 parts, 36 plates	Herr Beuth.

TITLE OF BOOK.	DONORS
Boundary Reports and Plans, England and Wales, 8 vols.	Mr. Barwise.
——— Scotland, 1 vol.	
——— Ireland, 1 vol.	
Bridge, Description of a, near Sangor, Central India, with two Lithographs	Mr. Gordon.
Calcutta Railway, Letter from the Directors	Captain Andrews.
Camus, M. on the Teeth of Wheels	Mr. Hawkins.
Canaux, de la depense et du produit des Canaux et des Chemins de Fer	Mr. Macneill.
Cements, Remarks on	Mr. Lowe.
Chambers' Dictionary, 4 vols. folio	Mr. Baker.
Civil Engineer's and Architect's Journal	The Editor.
Clark. Essay on Weights and Measures	The Author.
Compte Rendu de l'Administration du department de la Seine, et de la Ville de Paris, 1837	Prefect of the Seine.
Dictionaire Anglaise Francaise, 2 vols. 4to.	Mr. Wm. Cubitt.
Dorlegeblatter fur Maurer	Herr Beuth.
Egen, P. R. E. Effect einiger Wasserwerke	Herr Beuth.
Encyclopædia Britannica, Supplement to, 4 vols.	Mr. Field.
Eytelwein Handbuch, 3 vols.	Mr. W. B. Bray.
Glyn, J. On the Draining of Lands by Steam Power	The Author.
Godwin, G. Jun. Prize Essay on Concrete	The Author.
——— Chronological Table of Architectural History	
——— Appeal to the Public on Railways	
——— On the Obelisk from Luxor, recently erected at Paris	
Gordon, Alex. Observations on Railways and Turnpike Roads	The Author.
Grahame, Thos. Plan for passing the Clivities of Canals	The Author.
Gray, A. Ploughwright's Assistant	Mr. Hallen.

TITLE OF BOOK	DONORS
Hassler, F. R. Comparison of Weights and Measures	Mr. Blunt.
Hebert, Luke, on Railways	Rev. J. N. Wright.
Henry, D. I. Tables for finding the cubic contents of Excavations and Embankments	The Author.
Hood, C. On Warming Buildings by Hot Water	The Author.
Hutton, C. Mathematical Tables	Mr. Donkin.
——— Course of Mathematics	Mr. Hawkshaw.
Index of Places contained on Tanner's Map of the United States	Professor Henry.
Johnson's Dictionary, by Todd, 3 vols. 4to.	Mr. Bramah.
Journal of the Franklin Institute, vol. 19, 1837	The Institute.
Journal of the Royal Geographical Society, vol. 7, 1837	The Society.
Knight, P. Erris in the Irish Highlands and Atlantic Railway	The Author.
Knowles, Jas. Pronouncing Dictionary	Mr. Donkin.
Lacroix, S. F. Traite du Calcul des Probabilities	Mr. Bald.
La Mosaique Francaise Recueil de Literature, Art, Sciences, &c. No. 1	The Editor.
Le Lande, J. Tables des Logarithmes	Mr. Bald.
Letter to the Secretary at War in relation to a Canal from Lake Erie to Lake Ontario	Professor Henry.
Lingard, J. on the Decay of Timber	Mr. Gordon.
Macneill, J. Report on the Bann River Navigation	The Author.
——— Report on the Cork and Cove Railway	
Magazine of Popular Science, 2 vols.	The Editor.
Mining Journal, 3 vols. folio, and Continuation	The Editor.
Mining Review	The Editor.
Mudge, Colonel. Trigonometrical Survey.	Mr. Sibley.
——— Observations on Railways	The Author.
Mudie, Robert. Popular Mathematics	The Author.

TITLE OF BOOK	DONORS
Ordnance Maps of Ireland	The Lord Lieutenant.
Parliamentary Inquiry, relative to Arts and Manufactures	Mr. Jermyn.
———— Reports of the Select Committee on the Connaught Lakes . . .	Mr. Bald.
———— on Public Works in Ireland	
———— on Evidence, Oral and Documentary, received by the Committee on the Scotch Universities . . .	H. Warburton, Esq. M.P.
———— a second copy of the same	Mr. Dike.
———— of the Select Committee on the British Museum	
———— 1st and 2d on the Irish Fisheries	
———— 7th and 8th on the Management of the Post Office . .	
———— of the Inspectors of Factories	
———— on Railways in Ireland	
———— Account of Trade and Navigation of the United Kingdom .	
———— Income and Expenditure of Turnpike Road Trusts	
———— of Return of the number of Writs of Error	
———— on Mr. Barry's Plans of the new Houses of Parliament .	
———— Standing Order on Railway Bills	
Perry, Capt. Account of Stopping Dagenham Beach	Mr. Burges.
Pratt, Rev. J. H. Principles of Mechanical Philosophy	The Author.
Price, H. H. Report on the Bridgewater Canal and Docks	The Author.
Proceedings of the Royal Society from 1830 to 1837, 8vo.	The Royal Society.
Professional Papers of the Royal Engineers, 1837	Lieut. Denison, R.E.

TITLE OF BOOK	DONORS
Railroad, Account of the first Russian	Mr. Hawkins.
——— Several copies of the same	Mr. Kreeft.
Rapport, l'Exposition du Systeme pour eclairer les Cotes de France	Mr. W. B. Bray.
——— presente au Conseil Municipal de la Ville de Paris, 1837	The Prefect of the Seine.
——— sur le Administration Generale de la Ville de Paris, presente au Conseil Municipal	
Report of the Birmingham Philosophical Institution	The Institution.
——— of the Committee of the Franklin Institute on the Explosion of Steam Boilers	The Institute.
——— of the Committee of the Franklin Institute on the Strength of Materials for Iron Boilers	
——— of the Directors of the Manchester Mechanics' Institution	The Institution.
——— Fourth, of the Royal Cornwall Polytechnic Society	The Society.
——— of the Proceedings of the Owners of Property on the Banks of the River Hull	Mr. Oldham.
Russell, John Scott. Researches in Hydrodynamics	The Author.
Schlick, B. Memoir on the Thames Tunnel	Mr. Whishaw.
——— A Translation of the above	
Simms, F. W. Treatise on Levelling	The Author.
Statisque des Egouts de la Ville de Paris, 1836	The Prefect of the Seine.
Stevenson, A. Report on Illuminating the Lighthouses by means of Lenses	The Author.
——— Account of the Bell Rock Lighthouse	The Commissioners of Northern Lights.
——— British Pharos	
Sugar, on the Manufacture of	Mr. Hawkins.
Survey of a Ship Canal round the Falls of Niagara, 4 sheets	Professor Henry.
——— of a Ship Canal from Lake Erie to Lake Ontario, 2 sheets	

TITLE OF BOOK	DONORS
Transactions of the Institute of British Architects, 1835—6.	The Institute.
———— Architekten Vereins, Berlin, folio, plates, 1833—1835.	The Society.
———————— 4to. 1833—1835.	
———— of the Society of Arts for the Encouragement of Manufactures, &c. vol. I. part I. 1836	The Society.
———— of the Royal Society of Edinburgh, vol. XIII. parts I. and II.	The Society.
———— of the Statistical Society of London, vol. I. part I. 1837	The Society.
———— of the Statistical Society of Glasgow and Clydesdale, 1836	The President, Dr. Cleland.
———— of the Royal Society of London, for 1832, 1833, 1834, and 1835	The President.
———— of the Royal Society of London, 1836	The Royal Society.
———————— 1837, 1st part.	
———— of the Cambridge Philosophical Society, vol. V. parts 1, 2 and 3; vol. VI. parts 1 and 2, 1833, 1834, 1835, 1836, 1837	The Society.
———— of the Royal Society of Literature, vol. I. parts 1 and 2; vol. II. parts 1 and 2, and Supplement; vol. III. part 1, 1827, 1829, 1832, 1834, 1837	The Society.
Tredgold, T. Tracts on Hydraulics	Mr. Lynde.
Treusart. Memoires sur les Mortiers Hydrauliques et Mortiers ordinaires	Colonel Pasley.
Turnbull, T. On the Strength of Timber	Mr. Cottam.
Ure, Dr. On Ventilation and Warming Apartments	The Author.
Versuche mit Horizontalen Wafferradern	Herrn Wedding.
Vicat, J. L. Resume sur les Mortiers et Ciments Calcaires	Col. Pasley.
———— Recherches sur les Betons	Col. Pasley.
Vicat, J. L. On Cements, translated by Capt. Smith	The Translator.

TITLE OF BOOK	DONORS
Vignoles, C. Report on the Upper Works of Railways	The Author.
Walker I. and Burges. Report on the Improvement of Belfast Harbour	Mr. Bald.
Webster, T. The Elements of Physics	The Author.
Whishaw, F. Railway Reports	The Author.
——— Analysis of Railways	
White, I. Description of a new Railway Chair	The Author.
Whitehaven Harbour, Reports on	The Trustees of the Harbour.

Maps, Charts, Plans, Prints, Specimens, &c.

Bridge. Two Lithographs of one near Sangor, Central India	Mr. Gordon.
Bridge, model of Cutwaters	Mr. Bald.
Bridgewater Canal and Docks, Lithograph of	Mr. Price.
Brindley, Jas. Print of	Mrs. Col. Page.
Chart of Entrance to the Port of Liverpool, from the Ordnance Survey	Capt. Denham, R. N.
Cables. Ropes and Strands. Specimens of, made by Messrs. Huddart and Co.'s Machinery	Messrs. Huddart.
Clare Island, model of	Mr. Bald.
Liverpool, Gage's Trigonometrical Plan of	Dr. Gregory.
Map. Geological, of England	Messrs. Walker.
—— Of Railroads in England	
Maps, Ordnance, of England and Wales	Board of Ordnance.
——— Ireland, Counties of Cavan, Donegal, and Louth	Lord Lieutenant of Ireland.
Maps and Plans, Portfolio of	Mrs. Chapman.
Railroad, Westminster Bridge and Greenwich, View of	Mr. Paine.
Rennie, John, Print of	Mrs. Col. Page.
Swansea Harbour, Lithograph of	Mr. Price.
Whitehaven Harbour, Plans of	The Trustees.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1838.

Jan. 9, 1838.

W. CUBITT, Esq., V. P., in the Chair.

"On Captain Huddart's Improvements in Rope Machinery. By W. Cotton."

Huddart's Rope Machinery.

The attention of the late Captain Huddart was directed to the subject of rope-making, from observing every morning during a voyage that some of the external yarns of a ship's cable were broken.

This was evidently to be attributed to the additional strain which the outer yarns experienced in the process of twisting, the yarns being all originally of the same length. It was proposed to obviate this defect by giving to all the yarns an increased length in proportion to the distance of the yarn from the centre of the strand, and to the angle at which it was laid. The success which attended these efforts induced Captain Huddart to construct the large laying machine, which was found to answer completely, and to give to each strand its proper length and proper degree of twist, and to preserve throughout the longest rope the same press and the same angle.

The paper contains some historical notices respecting the establishment of the extensive works of Huddart and Co. at Limehouse, and the various stages of improvement. Several pieces of strand, to illustrate the foregoing principles, were presented, as also a piece of the twenty-two-inch cable made for the East India Company's ship Waterloo; a strand of the long rope made for the London and Birmingham Railway; and some cards containing the comparative strength of the warm and cold, registered and common, cordage.

Captain Huddart.

The distinguished individual of whose improvements in Rope Machinery a brief account has here been given, was born at Allenby, in Cumberland, in 1741, and died in 1816, after a life devoted to the pursuit of those scientific researches for which his rare talents so eminently qualified him.

In the strands as constructed on this principle the strain on all the yarns will be the same so long as the original degree of twist is preserved; but if the strand become untwisted, there is an extra strain on the internal yarns; if more tightly twisted, on the external yarns; several strands, however, being worked together in a cable, the twisting or untwisting of each particular one is prevented.

"On the Cornish Engines. By Thomas Wicksteed, M. Inst. C. E."

Cornish Engines.

In this communication Mr. Wicksteed gives an account of several trials which he made on some engines in Cornwall. In a trial of the engine upon the Holmbush Mines, the water was delivered into a cistern and weighed, and the result obtained by an experiment was 102,721,323 lbs. raised one foot high with ninety-four pounds of coal: this was the quantity raised and delivered. The quantity raised does not however express the duty of the engine, which must be calculated according to the contents of the pumps and the atmospheric column, without any allowance for leakage. According to this calculation, the duty would be nearly 118 millions; namely, 117,906,992 lbs. raised one foot high with ninety-four pounds of coal.

Another calculation is then given founded on the law of Boyle, that the pressure of the steam is inversely as the space occupied. The steam was cut off at one-sixth of the stroke, and the temperature in the jacket was fully maintained by free communication with the boiler. The mean pressure of the steam being (on the above law) 17·66 lbs. on the square inch, the power of steam would be 211,658,700 lbs. Now, as the duty would be 117,906,992, we have 93,751,710 for the friction of the machinery, or about 7¾ lbs. per square inch; which is about two pounds more than the friction of a water-works pumping engine.

Mr. Wicksteed also made trial of a double engine at the Tincroft Mines, working stamps, cutting off the down-stroke at ⅖ths, and in the up-stroke at ⅓rd. The duty of this engiue was 56,525,072.

The coals consumed by the Tincroft engines amounted only to

1·57 lbs. per horse power per hour; whereas in an experiment at Oldford, the quantity was 4·82 lbs. notwithstanding the additional friction in the former case of the mining engine. The consumption is stated by Mr. Farey in his Treatise on the Steam Engine, for a double engine (Boulton and Watt) at 10½ lbs. per horse power per hour.

At the end of the paper are two Tables, the one shewing the gradual improvement of the steam engine during 66 years, and the other the average duty of engines in Cornwall for 1835 and 1836. The improvement has been progressive from 1769 up to the present time, and it appears, on the authority of Mr. John Taylor, that on comparing the water raised and the coals consumed from 1799 to 1828, at different mines, there is a saving on the books of the mines proportionate to the improvements stated to have been made during these periods in the working of the engine.

Weight of Coal.

Some discussion then took place on the weight of the bushel of coals, Mr. Lowe stating that he had never known a bushel of Newcastle coals to weigh more than 84 lbs. Mr. Price stated, that the Welsh coal, which was chiefly used in Cornwall, was very heavy, and he had known a heaped-up bushel to weigh 101 lbs. The weight of the bushel of Newcastle coal was considered as varying from 80 to 84 lbs.

January 30, 1838.

The PRESIDENT in the Chair.

"On Locomotive Engines. By Edward Woods."

Locomotive Engines.

The first engines employed on the Liverpool and Manchester Railway, were found to require strengthening in almost every part. The increase of weight from five tons to seven tons, consequent on staying the inner and outer framings in every part, on replacing wooden by iron wheels, and of nearly doubling the quantity of material in the axles, piston rods, &c., rendered the engines too heavy for the road, which was formed to sustain a moving mass of not more than four tons and a half, on four wheels. The weights being still farther increased, it became necessary to relay the whole line, and, as a temporary expedient, to place props under the rails, and to add a third pair of wheels, behind the fire box. The author then details certain necessary conditions in the structure of Locomotives, and the means successfully adopted to obviate the rocking motion and the unsteadiness arising from lateral undulations; also other important practical results, which time developed.

The utility of an outside framing, and the practical advantages as regards steadiness in the motion and diminution of the injurious tendencies of concussion, are then considered. With respect to the objections urged against the use of six-wheeled carriages, that they have less adhesion than four-wheeled carriages; that the axle and weight detract from the available power; that the friction and strain are increased in traversing curves—the author observes, that the adhesion, though less, is sufficient; that the additional weight does not exceed 12 cwt., or produce a diminution in the tractive power amounting to more than $\frac{1}{200}$th of the whole; and that the strain and friction are entirely obviated by making the plummer blocks of the hind wheels light and elastic, so that they will readily yield sideways. The usual weight of the engines now in use on the Liverpool and Manchester Railway is about eleven and a half tons, and distributed as follows:—four and a half tons on the fore wheels, five tons on the driving wheels, two tons on the hinder wheels.

"On Improvements in Water Wheels. By Isaac Dodds."

Water Wheels.

The author having made many experiments with the view of removing the evils produced by back-water upon water wheels, was led to propose as a remedy that the wheel should be raised or lowered by means of two air vessels, which form the sides or water-guides to the wheel, as well as carry the weight of the machinery. These being properly ballasted, any required dip may be given to the wash boards. The race is so adapted that the dam head may be raised in the same proportion as the back-water, or more or less. The paper is accompanied by a plan and sections of the proposed machinery.

It was remarked, that the cases to which the proposed method would be applicable, are not of common occurrence in this country, as it is necessary that the head and tail should rise by the same amount. It generally happens that the tail rises more than the head. It is also only applicable to undershot wheels, which are seldom used except in cases of superabundance of water. The best practical rule for the engineer is, to give to the water wheel superabundant capacity, and to make it go very slow.

Mr. Brunel then gave an account of the new Poling Boards which he is employing for the effectual protection of the Shield at the Tunnel. These constitute a system of pannelling, of which every one, though it can be easily moved, is secured to its neighbour. Thus the boards cannot be displaced, and a most efficient auxiliary is provided against the loose portions of ground in front of the shield. The application of these appears to have added everything that was wanted to render the shield a perfect protection in all operations of a nature similar to those which are now going on at the Tunnel.

Thames Tunnel.

February 6, 1838.

The PRESIDENT in the Chair.

The following candidates for admission were balloted for, and duly elected:—Thomas Jackson Woodhouse, as a Member; Henry Carr, as a Graduate; David Mushet, Charles L. Francis, George Crane, Henry Kendall, and Henry Vint, as Associates.

"On the construction of Flat Roofs with Earthenware Pots. By F. W. Simms."

Mr. Simms details the construction of the roof of the Manutention des Vivres de la Guerre quai de Billy, Paris, formed of earthenware pots, and entirely without timber. This roof, which forms a flat terrace, having only inclination sufficient to carry off the water, is constructed with pots of about nine inches long, and five inches in diameter, nearly cylindrical, and closed at both ends; one end being finished off nearly square. The soffits of the arches are covered with plaster, and form ceilings. The extrados of the arch is covered with Beton, composed of lime, sand, and gravel, of such thickness as to give the inclination requisite for carrying off the water; on this is laid a thin coating of hydraulic mortar, over which, when dry, canvas is stretched tight, and upon the canvas Asphaltic Mastic is poured in a semi-fluid state, which forms the finished surface of the terraced roof.

Roofs of Earthenware Pots.

The paper was accompanied with a plan and section of the roof so constructed. The strength of part of this roof had been tested during its construction, and was found to bear six tons without yielding; it had also suffered no injury from the fall of a stack of chimneys upon it, excepting some bruises in the mastic, which were readily repaired.

Mr. Simms presented one of the pots employed, and exhibited several specimens of the Asphaltic Mastic in its manufactured state. He also exhibited some pieces of pots fastened together by the mastic, which had resisted great efforts to separate them.

Asphaltic Mastic.

The asphaltic mastic is obtained from Pyrimont, near Lyssell, and brought down the Rhone, and is a compound of a carbonate of lime and mineral pitch. After being roasted on an iron plate it falls to powder, or may be readily pounded. By roasting, it loses about $\frac{1}{40}$th its weight. It is composed of nearly pure carbonate of lime, with about nine or ten per cent. of bitumen.

When in a state of powder it is mixed with about seven per cent. of a bitumen or mineral pitch, found near the same spot. This bitumen appears to give ductility to the mastic. The addition of only one per cent. of sulphur makes it exceedingly brittle The powdered asphaltic is added to the bitumen when in a melting state; also a quantity of clean gravel, to give it a proper consistency for pouring it into moulds. When laid down for pavement small stones are sifted on, and this sifting is not observed to wear off. The mass is partially elastic, and Mr. Simms had seen a case in which a wall having fallen away the asphaltic stretched, and did not crack. It may be considered as a species of mineral leather. The sun and rain do not appear to have any effect upon it; it answers exceedingly well for the floors of the abattoirs of the barracks, and keeps the vermin down; and is uninjured by the kicking of the horses' feet. It may be laid down at from eightpence to ninepence per square foot.

Coals in Cornish Engines.

A letter was read from Mr. Wicksteed, in reply to some queries which had been addressed to him respecting the weight and quality of the coals used in the Cornish Engines, and the effect of the jacket.

According to some experiments of Captain Lean, it appears that the average weight of coals used at the Cornish Mines is 93 lbs. per bushel. The coals generally used are imported from South Wales; from Swansea, Neath, and Llanelly, and are of the *second* quality, the large being selected for the steam boats. Of the various sorts imported into Cornwall, some are light and dead burning, and run through the bars like sand; some contain slate rubbish; some coke well, and give out much heat. The weights of the bushel of these different kinds of coals vary from 80 lbs. to 112 lbs. The coals as taken from the wharf contain about ⅛th of their weight of water. The coals are sometimes damped to make them coke, but the drier they are the better. Some of Price's coal, from Swansea, is very bituminous, and is mixed in equal proportions with the Quaker's coal, from Neath, some of which is not bituminous. From the practice of different engineers it appears, that when the coals are light and small, there is a greater loss from their falling through the bars and being carried into the flues, before ignition, than accrues from the process of damping.

Mr. Wicksteed details some experiments made at Oldford on the weight of the Bradley Main Newcastle coal. It appears that the weight of the bushel, or of 1·63 cubic feet, is 92½ lbs.; of these 15½ lbs. were large, the smallest of which would not pass a gauge 1⅓ of an inch square; 28¾ lbs. would not pass a gauge ⅝ths of an inch, and 48¼ lbs. were small coal and dust.

Effect of the Jacket.

Mr. Wicksteed had taken an account of duty done during three days by an engine, sixty-inch cylinder, *with* steam in the jacket, and *without* steam in the jacket; and it appears that the duty in the former case was to that in the latter as 100 to 90; or the jacketting effects a saving of ten per cent. The quantity of water condensed in the jacket, during 216 strokes, amounted to two per cent. of the water evaporated for working the engine.

Work and Duty done.

A discussion then took place on several parts of Mr. Wicksteed's paper, read at the preceding meeting. With respect to the duty as estimated by the water delivered at the surface, or by the number of strokes, Mr. Wicksteed contended, that though the work done or real effect amounted only to 103 millions, the duty performed was really 118 millions, for the water displaced and lifted each stroke must be equal to the area of the plunger multiplied into the length of the stroke. The engine will have once received the water, whatever loss may be due to the imperfection of the pit work.

Application to Water Works.

It has been urged that the Cornish system of pumping could not be applied in Water Works, where the water is to be forced directly into the main, or where the work has the irregularity consequent on the variation of pressure in the mains, and that the action of the high pressure steam might in the first instance burst the pipes. But if the load and its velocity are proportioned to the power of the engine, it cannot matter whether the load is distributed in long shaft rods or in any other form; that the supposition of the work being regular and steady in mines is erroneous; the variation is great, though not so great as in water works. The Cornish engine now erecting at Oldford has a steam cylinder of eighty inches diameter, and ten feet four inches stroke, and it is proposed to work it at about eight strokes per minute. The diameter of the plunger pole pump is forty-one inches, and stroke nine feet four inches; the pumprod will be made with moveable weights, its greatest load being 74,000 lbs. Mr. Wicksteed described several arrangements which would be made for the purpose of regulating the load and working of the engine. There is a great advantage in being able to work an engine from half a stroke to twelve strokes per minute, since the coals consumed are nearly in proportion. The best velocity however appears to be from five to nine strokes per minute.

Friction of an Engine.

The friction of the Holmbush engine, according to a calculation in Mr. Wicksteed's paper, is 7¾ lbs. per square inch; the friction as ascertained in an experiment at Oldford, amounted to 5¾ lbs. per square inch. The additional allowance of 2 lbs. per square inch, for the friction in a Cornish engine, does not appear too much when the circumstances under which the engine works are considered.

Duty of Double Engines.

The President inquired as to the cause of the difference of duty in the stamping engine and in the single acting pumping engine. It was stated in reply, that the friction is much greater in double than in single engines; that the same difference existed in the Boulton and Watt low pressure engines as in the high pressure expansive engines.

Coals per Horse Power.

Various opinions were entertained as to the allowance of coals per horse power per hour. According to Mr. Farey, the allowance is 10½ lbs. per horse power per hour for a double Boulton and Watt engine. Watt's own allowance was 8 lbs. and in one case of a new engine using high pressure steam expansively, 5 lbs. had been found sufficient. The superiority of the Cornish engines was to be attributed to working high steam expansively, and to the improved method of generating steam, and complete system of clothing which was adopted. The economy of fuel was pushed to a great extent in Cornwall, the fire-places are very large, and the combustion very slow and the refuse worthless. They have no tall chimneys, and the dampers are kept very low. Attention to the management of the fires is of the greatest importance, and, as a general rule, the damper should be kept as low as possible, a high temperature should be maintained, and the less frequent the stoking the better.

Feb. 13, 1838.

The PRESIDENT in the Chair.

The following were balloted for, and elected:—John Braithwaite and Charles Fox, as Members; F. W. Simms and C. H. Gregory, as Graduates; Thomas Evans and Apsley Pellatt, as Associates.

Application of Steam.

The minutes of the discussion on Mr. Wicksteed's paper and the Cornish engines having been read, Mr. Parkes called the attention of the Institution to the importance of the question of the applicability or inapplicability of the Cornish system of using steam in condensing engines generally. It seemed to him, after the confirmation which the statements regarding the Cornish engines had lately received from the praiseworthy exertions of Mr. Wicksteed, that, as regards economy of fuel, the Cornish engine was even still more superior to the low-pressure engine, than the latter was (at the period of its invention by Mr. Watt) to the original atmospheric one; that there existed, indeed (if all we heard were true), less economical difference between Mr. Watt's and the high-pressure or non-condensing engine, than between the Cornish and the common Boulton and Watt engine. If such were the case, which could now scarcely admit of a doubt, Mr. Parkes thought, that the interests of science and the arts demanded a much more thorough and searching investigation into the rationale of the Cornish engine, than had yet been made; and he thought it a reproach to the Institution, that no one of its Members is yet prepared to say, whence arises the superiority of the Cornish engine, nor what is the relative value of the various perfections which had been for so many years assigned to it by its employers.

Mr. Parkes thought, that most engineers were agreed, that the low-pressure crank-engine used for manufacturing purposes required, in its highest state of condition, at least 10 lbs. of good coal per horse per hour; that such was Mr. Watt's own estimate, allowing 1 lb. of coal for the evaporation of 7 lbs. of water. He had had many opportunities of proving—so far as the Indicator can be relied upon—the load and consumption of Boulton and Watt's own engines, as well as engines by other makers; but only in three instances had he found the consumption so small as 10 lbs. He had only in one instance been concerned in ascertaining the duty done by a pumping engine—which was one of the same kind—not working expansively; and as this experiment was conducted with the most rigorous exactitude, the correctness of the results might be relied upon. The engine was nominally one of 40 horses' power, constructed by Messrs. Hick and Rothwell, of Bolton, erected at St. Ouen, near Paris, and employed to raise water, by means of a scope wheel, to supply a new dock. The experiments of two consecutive days were managed and checked by M. Arago, M. Jouy, Mr. H. Farey, and Mr. Parkes. By the Indicator, the engine proved to be working exactly to 40 horses' power, with a consumption of 11 lbs. of good Mons coal per horse per hour: but as the actual weight of water raised, one foot high per minute, divided by 40 horses, attained 36,000 lbs., the real consumption was about 10 lbs. of coal per horse per hour. Mr. Parkes adduced this experiment, with an engine of the most perfect construction and in perfect condition, as evidence, that the duty of the common low-pressure crank-engine, not working expansively, does not exceed 20 or 21 millions of lbs. raised one foot high by 90 or 94 lbs. of coal—and thus that the Cornish engine investigated by Mr. Wicksteed exceeds such engine, in economy of fuel, in the ratio of 5 to 1.*

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* In the last line of page 2, of the Minutes, instead of Tincroft engine, it should have been Holmbush engine. The Tincroft double engine consumed 3·25 lbs. of coals per hour per horse power; whereas a double engine, according to Mr. Farey, consumes 10½ lbs. The following table exhibits the comparative value of different engines in lbs. of coals per horse power per hour :—

Cornish Pumping Engine	1·57
Boulton and Watt Single Engine . . .	4·82
Cornish Double Engine	3·25
Boulton and Watt Double Engine . .	10·5

Hence the superiority of the Cornish Pumping Engine above the Boulton and Watt Single Engine, is very nearly as 3:1; and the Cornish Double Engine above the Boulton and Watt Double Engine in the same proportion; and of the Cornish Pumping Engine above the common condensing, for manufacturing purposes, as 6½ to 1.

Mr. Parkes then entered at some length into a consideration of the various phenomena to be observed, and facts to be ascertained, in order to determine the separate value of the parts of the system adopted in Cornwall. The assertion that the boiler was superior to others, would be confirmed or disproved by measuring the water evaporated by the fuel used—which might also be done with such accuracy, as to furnish us with the very important knowledge of the quantity of water in the shape of steam required for each stroke of the piston. A thermometric steam gauge should be fixed on the boiler, and another as near as possible to the cylinder, to determine both the pressure within the boiler, and at what pressure the steam really enters the cylinder. He suggested also that another such thermometer, fixed on the cylinder cover, might be useful, in conjunction with the Indicator, to determine the increments of expansion, as well as the highest and lowest degree of pressure within the cylinder. That it appeared to him the Cornish engineers had carried out to perfection Mr. Watt's axiom, that "the cylinder should be maintained as hot, and the condenser as cold, as possible," and that since the hot jacket probably played a still more important part to the cylinder of an expansive than to a non-expansive engine, no means should be left untried to ascertain the value of that element. That the thermometric steam gauge might also be an useful adjunct to the barometer, in determining the amount of vacuum in the condenser, and other phenomena connected therewith. The proportions of the air-pump and condenser to the cylinder, adopted by the Cornish engineer, should also be noted, as well as the temperature of the injected and ejected water.

Mr. Parkes then exhibited a sketch of the thermometer employed by him in many experiments on the engines working the steam plough, and stated his confidence in the accuracy of these instruments as constructed by Mr. Adie, of Liverpool, and which were now much used on the locomotive engines.

Arch without Centring.

Mr. Brunel exhibited a model illustrative of his method of constructing an arch of large span without any centring.

Joyce's Stove.

Mr. Newton exhibited the heating apparatus invented by Joyce. The fuel was stated to be charcoal, so prepared that the carbonic acid gas given out during combustion is absorbed. The rate of combustion, and consequently the temperature of the vessel, is regulated by a valve at the top.

February 20, 1838.

The PRESIDENT in the Chair.

W. Handyside was elected a Graduate; and C. H. Capper, H. Rowles, S. J. Knight, and T. G. Hardie, were elected Associates.

Indications of the Thermometer.

The Minutes of Conversation having been read, some discussion arose on the reliance to be placed in the indications of the thermometer, when the changes of temperature are great and sudden. It was observed, that the mercury of the thermometer requiring time to lose and acquire heat, the variations in the pressure due to the change of temperature would be indicated with far greater certainty by a column of mercury; but that the thermometric gauge would be free from the oscillations accompanying the mercurial column under similar circumstances, which rendered such observations inaccurate.

Mr. Wicksteed's Papers.

The President remarked that, as the subject of Cornish engines had usefully occupied the attention of the Institution for part of several evenings, he thought it right to remind the meeting of the obligation due to Mr. Wicksteed, by whom it was introduced, through the medium of his first paper, written after his return from a professional visit for the East London Water Works Company, and read at a former session. After the reading of this paper, doubts were expressed as to the correctness of some of the results, as they so far exceeded those of the common condensing engine; and it was suggested, that until full experiments were made, by pumping water and measuring it, or raising weights and weighing them, the doubts were likely to remain. Mr. Wicksteed again visited Cornwall, when he made other experiments, and weighed the water and weights in the way described in his report, and the result was, the very valuable paper which had given rise to these discussions. So far as he knew, Mr. Wicksteed was the first who had weighed the water raised in this large way. The consequence probably was, the removal of many of the doubts which had been previously entertained of high steam and working expansively. The increased effect of high steam, when worked expansively, was well known to Watt, and is evident, if the action of the elastic fluid in the cylinder be considered; but the danger which appeared to be attendant upon high steam, when the means for preventing that danger by improved machinery and boilers were less perfect than at present, prevented him from adopting it. In pumping, then, and in most rotary engines, there was an evident saving by using the high steam, shutting off and working expansively; but there appeared some irregularity in the motion in expansive working for very fine machinery. Mr. Jackson of Leeds had surprised him by saying, that by cutting off the steam in a low-pressure engine, even at $\frac{4}{5}^{\text{ths}}$ of the stroke, the effect of the irregularity was sensible, by breaking the very fine flax thread manufactured by Messrs. Marshall. He thought it right to make these remarks in expressing his thanks, which he was sure were due to Mr. Wicksteed for his valuable communications, and he hoped that his example would be remembered by those engineers who were employed in similar professional inquiries.

In reference to the preceding remark on the effect of cutting off, it was stated that several engines in Lancashire, driving fine cotton machinery, were now working more or less expansively without inconvenience. That the irregularity spoken of was easily overcome by heavier or more rapidly revolving fly-wheels, or by two engines coupled together.

On the Expansive Action of Steam in Cornish Engines. By W. J. Henwood.

Indicator.

At the commencement of this paper, the author describes, with great detail, the action of the Indicator, and the nature of the evidence which it furnishes on the working of an engine. The author then states the results arrived at on applying the Indicator to the cylinders of some of the best engines in Cornwall. The peculiar circumstances of each case, as the clothing of the boilers, steam pipes, and the various methods adopted for keeping up the temperature of the cylinder, are detailed. The steam cases or jackets of some of the engines were filled with dense steam from the boilers, of others with heated air. The dimensions of the working parts and the loads of the engines; the water and steam in the boilers; the temperatures of the hot well of the condensing water, of the boiler shed, engine house, and external air; the duration of the experiments; the coals consumed, according to weight and measure; the quantity of oil and grease; the number of strokes; the duration of each experiment, and the pressures of the boiler and cylinder, are tabulated for the respective engines.

Duty. The greatest duty performed by the measured bushel, by 84 lbs. damp, and by 84 lbs. dry, is respectively 86½, 72½, and 77½ millions.

Expense. This paper also contains a calculation, as to the expense of performing a given quantity of work, and it appears that, a proper allowance being made for the coal, grease, and oil consumed, there was raised by Huel Towan engine 1,085 tons, and by Binner Downs 1,006 tons, one foot high for one farthing. According to this result, the weight of a man (1½ cwt.) would be raised ten miles for a penny.

On the Dry Meter. By S. Clegg.

Clegg's Meter. This instrument, originally designed for measuring gas, may be applied to other useful purposes, as to register the average pressure of high-pressure steam, the average temperature of heated air, or the average of any variable temperature for any period. The principle of action in this instrument, is the evaporation of spirits of wine, which is well known to vary *directly* as the heat. The spirit of wine is contained in a pulse glass, the connecting stem being bent round, so that the two bulbs are brought nearly into contact with each other; the glass revolves about an axis perpendicular to its plane, the axis being so placed, that when the upper glass is filled with the spirit, the centre of gravity should be a little beyond the vertical, through the point of suspension, and consequently the upper bulb descends. In the frame-work of the instrument are two orifices, opening directly on the upper and lower bulbs, but of different areas, the lower orifice being somewhat the larger; through these orifices currents of gas are passed by means of tubes, the gas having been previously conducted to the under-side of a gas-burner, so that the gas in its passage may be heated. It is then ascertained by actual experiment, what quantity of heated gas will cause the spirits from the lower globe to be driven into the upper one; this once ascertained, may be always depended upon. The spirit of wine having ascended from the lower to the upper globe, the descent of the upper one gives motion to wheel-work, whereby the number of these oscillations, and consequently the number of volumes of heated gas which have passed through the tubes, may be registered.

Feb. 27, 8138.

The PRESIDENT in the Chair.

Charles Dixon, W. W. Howe, were elected Graduates; and A. Thompson, J. Stansfield, R. Nicholson, were elected Associates.

Prepared Charcoal.

Some discussion took place on the method of preparing charcoal, which might be burnt without danger. It was stated that charcoal, broken into small pieces, and steeped in a mixture composed of two gallons of water, one pound of quick lime, and ten ounces of salt, could be burnt at a slow rate, without the evolution of carbonic acid gas being sensible. It is known that lime will never absorb more than from 62 to 64 per cent. of the carbonic acid gas of which it has been deprived by burning; also one pound of charcoal will, during combustion, produce as much carbonic acid as can be absorbed by three pounds of lime.

On the Thermometric Steam Gauge. By Mr. Adie.

Thermometric Steam Gauge.

A letter was read from Mr. Adie, on his improved form of this instrument. He uses strong bulbs, and cements the tubes into a brass collar, so as to be firm and perfectly tight. The tube being fastened at no other point, suffers no injury from the contraction and expansion of the scale. The standard scale was graduated as follows:—A mercury column, and one of the Thermometric Steam Gauges, carefully graduated to temperature, according to Fahrenheit, were attached to the boiler of a Locomotive, and the temperature for given pressures being accurately noted, a scale was obtained by which the Thermometric Gauge is now graduated to pressures without any degree of temperature. The omission of the graduations for the temperature, is found convenient in practice. This letter was accompanied by one from Mr. Woods, the resident engineer of Liverpool and Manchester, in which Mr. W. states, that he has used the Gauge on the Locomotives on that railway during the last two years, and found it a very accurate and convenient instrument.

On the Brick Beam at Nine Elms.

Brick Beam.

Two communications on the Brick Beam were read, the one from Mr. Charles L. Francis, and the other from Mr. Hemans.

These papers, which were accompanied by drawings, described the general structure, and the breaking of the beam. The beam consisted of nineteen courses of brick, laid in cement, gauged with equal portions of clean sharp river sand. Between the first and second, and three succeeding courses, three lengths of an inch-and-a-quarter iron hooping were extended from end to end. Between the sixth and seventh courses two hoops were inserted, and between the eighth and ninth only one length, in all fifteen lengths. The distance between the piers was 21 feet 4 inches; the depth of the beam 4 feet 9 inches, and its thickness 2 feet, for the first six courses, and 1 foot 7 inches for the remainder. There was a slight deflection of about one-eighth of an inch from the first. The load was suspended in a cradle, being as nearly as possible in the centre, and when it amounted to 22 tons, 12 cwt. 1 qr. the piers slightly diverged, and the beam cracked exactly in the middle, opening like the hinge of a rule, and the fracture being clean and sharp, the cut being through both the cement and brick, as if a solid block had been rent. Eleven of the iron hoops broke as short as the bricks themselves, and four drew out of the opposite face of the fracture, the longest by about five inches.

Mr. Francis is of opinion, that the hoop had little to do in imparting strength to the structure--that the principle of tension could not be brought into play, since the adhesion being supposed perfect, there cannot be tension of one material without the other. Now cement is inelastic and inextensible, consequently the moment the elastic strain of the iron is called into play, the adhesion is irrevocably disturbed. The iron then being prevented from extending, may be considered as wrenched asunder by the same force as that to which the incorporated mass yields.

A long discussion ensued, as to the effect of the iron in sustaining the load. The closeness of the fracture proves the perfect adhesion of the iron and the cement, but the quantity of iron was too small to form a fair trial of the value of this mode of construction. The adhesion betwixt the iron and the cement being complete, the iron could not take the load unless by the yielding of the cement. Hence the different tiers of iron hooping may be considered as rent asunder in succession by the momentum of the mass, after the cement had yielded.

Mr. Mushet presented some specimens of malleable iron, in his opinion particularly adapted for railway purposes. The feature peculiar to this iron, is the omission of the refining process in its manufacture. The valuable properties of malleable iron being fibre and hardness, Mr. Mushet considers that these are but imperfectly secured by the present process; iron, as at present generally manufactured, receives the fibre from repeated heating and rolling. But fibre thus acquired is acquired at the sacrifice of hardness. The fibre of malleable iron may be injured by over-heating, by adding in the smelting furnace ores rendering the iron cold-short, or by the use of cinders, which, when in excess, cause the fibre to crystallize and produce brittleness. Some irons, however, are so exceedingly fibrous that they admit of a limited use of cinders without deterioration. By omitting the refining process, a greater mass of fibre can be produced than by any other means, and this fibre, in consequence of the iron not being exposed to so severe a degree of decarbonization, is stiffer and harder than that acquired by repeated heatings and rollings. The iron used for railways should be from good grey pig iron, as the source from which the hardest and strongest fibre in malleable iron is derived. The use of cinder pig should be excluded, on the ground that the quantity and quality of the fibre is injured, and if in the state of grey iron, its fusibility is so much increased as to occasion great waste in the puddling and re-heatings.

Iron for Railways.

March 6, 1838.

The PRESIDENT in the Chair.

W. Romaine and W. Bazalgette were elected Graduates; and James Pim was elected an Associate.

On the Evaporation of Water from Steam Boilers.

By Josiah Parkes, M. Inst. C. E.

In this paper, the author has brought together all the well-authenticated documents relating to the power of coal in producing steam, and thus exhibited, at one view, the present state of this department of science.

Evaporation of Water.

In the course of a series of experiments, undertaken with the view of diminishing as much as possible the loss and nuisance arising from the volumes of unconsumed smoke and soot which are emitted from the chimney, it appeared that, for effecting this purpose, the air necessary to render the smoke combustible must be given directly to the uninflamed gas, and not allowed to become vitiated by passing over inflamed fuel; that it must be administered at the point of greatest heat, the temperature of incandescence at least being necessary for its inflammation. Mr. Parkes was led therefore to admit the air at the bridge of the furnace. The effect of different modes of firing being observed, it appeared that less smoke was emitted from less frequent than from more frequent firing—that more water was evaporated by the same weight of fuel—and that fewer cinders and less scoria were produced. Pursuing this principle, he was led to work the engine with two charges of coal per day; the furnace being loaded at first in the morning as rapidly as keeping up the steam would permit, and then again at dinner-time. On this plan, great economy was attained, which was increased still farther by enlarging the furnaces so as to enable them to contain the entire fuel requisite for one day's consumption. The consequence was, that from 7 o'clock in the morning no smoke was visible; the dampers were kept very close down, and the steam not varying $\frac{1}{8}^{\text{th}}$ of an inch in height during many hours. At dinner-time the dampers were as closely shut as safety would permit, and a large quantity of water supplied. At night, when the engine was stopped, fresh water was supplied; thus the heat of the flues was taken up, and waste consequent on blowing off avoided. The boilers being well clothed, there was little loss of heat during the night. Mr. Parkes then describes in detail the method of firing which he had been led to adopt, and which was attended with such beneficial results, and by pursuing which he was enabled to evaporate 10·31bs. of water at a temperature of 212° by 1 lb. of coal, whereas the mean of the ordinary system of firing is only 7·5lbs. of water, evaporated by 1 lb. of coal. The greatest evaporation was 18½ cubic feet of water, at a temperature of 212° for 112 lbs. of coal. In order to raise steam with economy, the surface of water in the boiler ought not to be less than 10 square feet per horse power; the usual allowance in Lancashire is 7½ square feet; and 5 feet by Messrs. Boulton and Watt. The surface exposed to heat in waggon-shaped boilers is, respectively, about double these quantities, exclusive of any internal flue.

The system above described was subsequently made the subject of a patent, and applied to more than 500 furnaces, but has fallen in a great measure into disuse, simply from the fact that it depends on the fireman, and the master will not take the trouble of understanding it in order to save a few coals. This was precisely the case with the Davy lamp. The miners persisted in working in constant danger and with imperfect light, rather than adopt a contrivance requiring a small amount of trouble and care.

The author then points out some facts, with which we are at present unacquainted, but which are of the greatest importance to practical science—as some measure of the absolute quantity of caloric in a pound of coal or other combustible; the proportion in which air and fuel unite during combustion; the relations betwixt the combustible and the supporter of combustion; the relative heating power of the solid and gaseous portions of the coal, as exhibited in all the intermediate varieties from anthracite to cannel; the latter of which has been known to emit 85 per cent. of gas. Experiments are also wanting on the relative heating power of coal and coke. Mr. Parkes has found that 75lbs. of coke produced from 100lbs. of St. Etienne (French) coal, evaporated as much water as 100lbs. of the same coal. The explanation of this fact is seen, on considering that the heat of combustion does not depend solely on the combustible, but on the quantity of oxygen united with it.

The paper is accompanied by several tables; the first table shews the results of a great number of experiments in London and Lancashire, on the common or waggon-shaped boilers, fired on the old and the author's system. It exhibits the weight of coal consumed in raising the water to 212°, and in evaporating it from that point; and shews the effect to be attributed to the gaseous and carbonaceous matter.

In the second, the water evaporated by the Cornish boilers, at the United Mines, during the last eight months, is recorded. It appears that the greatest is 15·3lbs., the least 9·6lbs., and the mean of all the experiments is 11·8lbs. of water evaporated from a temperature of 212°, with 1lb. of coal. The result of Mr. Henwood's experiments, as detailed in his paper, is 14lbs. of water evaporated with 1lb. of coal.

The third table, founded on the experiments of M. de Pambour, contains the quantity of water evaporated in locomotive boilers; the mean of these experiments appears to be 5·6lbs. of water for 1lb. of coal, on the assumption that $\frac{8}{10}$ths of a lb. of coke is equal in strength to 1 lb. of coal.

The fourth table gives a comparative view of the whole, which shews that the value of the mean of the Cornish, Warwick, London, Lancashire, and locomotive experiments respectively is 21, 18⅓, 14, 13½, 10 cubic feet, evaporated by 112 lbs. of coal, from water at 212°.

The waste of heat arising from not covering boilers and steam pipes is also shewn by direct experiment. The author invites experimenters on this subject to supply, in every instance, the following information :—

The form and dimensions of the boilers ;

The area of the grates ;

The surface exposed to heat, distinguishing the area of that exposed to receive the radiant from the communicative heat ;

The temperature of the water entering the boilers ;

The exact weight of coals burnt ;

The exact weight or measure of water evaporated ;

The duration of the experiment.

Cement and Iron Hooping.

The minutes of the discussion on the brick beam having been read, Mr. Brunel stated, according to his experiments, continued during three months, every thing was to be attributed to the iron hooping. His experimental structure had cracked in several places, these cracks had been filled up with cement, and the arch had finally broken in a fresh place. Had the strength of the structure depended on the cement and not on the iron, the arch would have gone at first.

Mr. Brunel then described his method of measuring the tensile force of iron hooping, in structures of this nature. To the under side of each of two pieces of wood, joined by a hinge, is attached a beam of brick and cement, with iron hooping. Weights are laid on the upper side of the wood at the joint, and supported simply by the tensile force of the iron.

On the Strata of Stone in the neighbourhood of Whitby.

By N. King.

Whitby Stone.

This paper, accompanied by specimens of stone, in cubes, described generally the nature and properties of the stone from Whitby. Specimens, similar to those presented, had been tested by a Hydro-mechanical press at Messrs. Bramah and Robinson's, and their weights, and their fracturing pressures per square inch, are tabulated for the different kinds of stone.

March 13, 1838.

JOSHUA FIELD, V. P., in the Chair.

R. Rigaud and W. Jeakes were elected Graduates; Captain Brandreth, G. White, J. J. Sylvester, and B. L. Vulliamy, were elected Associates.

On the Floating Bridge across the Hamoaze from Devonport to Torpoint.

By James Rendel, M. Inst. C. E.

Rendel's Floating Bridge.

The floating bridge now described is used as a system of communication betwixt the opposite shores of the Tamer, a little to the north of Devonport. The width of the river at this site is 2550 feet, at high water, and its greatest depth at spring tides 96 feet. The ordinary velocity of the stream is 3¾ knots an hour, but under heavy land floods, it is increased to 5 knots. The line of passage is directly at right angles to the current; this, combined with the exposure of the site, and the rapidity of the current, rendered an attempt to apply a twin boat, similar to those at Dundee, a total failure.

The floating bridge is a large flat-bottomed vessel, of a breadth or width nearly equal to its length, namely 60 feet long, and 50 feet wide, divided in the direction of its length into three divisions, the middle being appropriated to the machinery, and each of the side divisions to carriages and traffic of all kinds. These side divisions have decks, raised from 2 feet to 2 feet 6 above the line of floatation, and carriages, horses, &c. pass on and off the deck by strong commodious platforms or draw-bridges, communicating with the landing-places, and over which carriages of all kinds drive on and off the bridge without difficulty or inconvenience.

The bridge is guided in its passage by two chains, which, passing through it, over cast-iron wheels, are laid across the river, and secured to the opposite shore; thus forming, as it were, a road, along which the bridge is made to travel forward and back from shore to shore. The peripheries of the wheels are cast with sockets, fitted to the links of the chain, so that when the wheels are stationary the bridge is moored by the chains; when the wheels revolve, the bridge moves in the opposite direction. Two steam engines, of 11 horse power each, are employed to turn these wheels.

The author then describes the details of the wood-work, and the dimensions of the several parts; the draw-bridge, and the landing-places, or inclined planes, formed on each shore; the galleries; the engine-house and machinery; the chains and balance weights; the accommodation, and regulations of the bridge.

The peculiar feature in these works are the balance weights. There would have been great difficulties in fixed moorings; the ends of the chains are attached to weights, suspended in shafts 16 feet square, and 20 feet deep, sunk in the landing-place above high water-mark. The weights are cast-iron boxes, loaded with about five tons each. Thus the additional length, requisite when the vessel is in the middle of the river, is obtained. Were the chains fixed to the shores, they would be too short, and consequently unnecessarily strained at this time, or so long as to allow the vessel to make lee way in her approach to the landing-place. This is altogether avoided by the balance weights; for as the vessel leaves the shore, the weights rise, and the chains lengthen, so as to adjust themselves to an easy curve; and as it approaches the other shore, the balance weights on that side fall, the chains are shortened, and the draw-bridges or platforms are brought straight and steadily to the landing-places.

The economy, both as regards first cost and annual expenses of these floating-bridges, no less than their superior accommodation to every other mode of crossing estuaries, has already given Mr. Rendel the opportunity of establishing several: the latest was that at Southampton, across the Itchin ferry, over which there are twelve coaches daily, and great carriage traffic, although the public have the option of crossing a fixed bridge over the same river, and only a short distance farther round.

The Lords Commissioners of the Admiralty having sanctioned the establishment of a similar bridge across Portsmouth Harbour from Portsmouth Point to Gosport Beach, a bill is now before Parliament to incorporate a company for carrying the work into effect. The great national importance of this harbour, and the well-known jealousy of the Board of Admiralty in all matters connected with its economy, furnish the best proof that these bridges, though requiring chains to be laid across the river, do not occasion the slightest impediment to the navigation or tidal currents.

The paper on the floating bridge having been read, Mr. Rendel stated that the chains were kept bright by the rubbing which they received on the bed of the river. The bed consisting of mud and not of gravel, the chains only scoured, and did not perceptibly wear. The chains which have been in use four years have not been sensibly diminished. They had tried chilled segments—these wore the chains; they consequently returned to good grey iron. Three sets of segments are worn out in the course of a year. In reply to a question respecting the deviation of the bridge under the action of the wind and current, Mr. R. stated, that he had never known it diverge more than by its breadth, or 50 feet; owing to the particular form of the bridge, and the small draft of water, the current had but little effect.

The usual weight of the balance boxes is five tons; but in hard weather, it is usual to add a ton more. He conceived that no comparison could possibly be instituted betwixt the relative advantages of the floating bridge and the twin boat; the latter requiring very expensive wharfs—those at Dundee, for instance, having cost upwards of £25,000, and still there is much attention and care required in bringing the boats to their piers. But the floating bridge requires no such expensive appendages; the chains on which it works, when the wheels are in motion, becoming the most secure fastening when the engines are stopped. The chains also act as a pilot and crew, two persons only being required in a vessel of this kind, viz. an engine-man and one on the decks to attend to the drawbridges.

Mr. Vignoles remarked, that the plan now proposed would obviate many difficulties which occurred in the case of rail-roads; there were many situations in which the floating bridge might be adopted with great service, and he could not refrain from expressing his admiration of the great forethought, skill, and design, which were here exhibited; at the minuteness with which the details had been studied; and, not the least, the adaptation of the balance weights for the chains; the chains not having elongated, proves of itself how completely they answered their intended purpose.

Thames Tunnel.

Mr. Brunel stated that the new system of poling boards, which he had exhibited to the Institution, had been very successful. They had supported ground in which the water was as six to one; the water passed through them and the men pushed on; the men could not have stood to the work without them.

March 20, 1838.

The **PRESIDENT** in the Chair.

The following were balloted for and elected: R. Roberts, as a Member; H. Marten, W. Crawshay, A. Murray, J. Bethell, as Associates; the Lord Viscount Lowther, as Honorary Member.

Floating Bridge.

The abstract of the paper on the floating bridges having been read, Mr. Rendel remarked, that as the same velocity could not be acquired in the manner proposed, as by a paddle-boat, the question to be considered was, as to the advantage of employing the floating bridge in preference in particular cases. They had to consider to what width of ferry the floating bridge is applicable; what the maximum velocity; what the expense of piers for paddle-boats. The great disadvantage of paddle-boats results from the difficulty of making fast, and of getting the cargo on and off. If we take as the measure of advantage the facility afforded by the floating bridge, then its superiority is very great. But the question is one of time, as well as of accommodation. He was of opinion, that a velocity of more than eight miles could not be attained by these boats. Now if a paddle-boat could be impelled ten miles an hour, the time of landing, which would amount to ten minutes, would compensate for the increased speed.

He conceived that the chain might be applied to a distance of three miles; the time of crossing and the expense of the chain were the only limits. Mr. Parkes remarked, that Mr. Rendel undervalued the advantages of his plan. In crossing the Mersey, for instance, excepting at high and low water, they had to run up or down, whereas the floating bridge would go straight across. There was great loss of time and uncertainty with the paddle-boats. They were frequently only a quarter of an hour in crossing the Mersey, but he had himself been three quarters of an hour in crossing from Liverpool to Birkenhead. A simple beach being sufficient for landing was a great gain, whereas to get paddle-boats alongside, extensive and expensive piers are required.

"The Land Surveyor's Calculator." By George Heald.

Land Surveyor's Calculator.

The instrument to which the above name is assigned was invented for the purpose of avoiding the necessity of performing long arithmetical calculations in surveying estates; the results are given at once by the adaptation and inspection of the instrument. It may also be applied to extracting the square roots of numbers, and to the other purposes to which the Gunter's scale is applicable.

The instrument consists of five concentric circles, whereof the four inner ones are on the outer edge of a card moveable about a centre, and the fifth on the outer circle is fixed. The circumferences of the two outer circles—that is, of the fixed circle and the circle at the edge of the moveable card—are divided into 1000 logarithmic portions representing links, the divisions being carried round in a contrary order, on the two circles. The third circle is divided to represent acres; the fourth to represent perches, and the fifth, or innermost circle, expresses the area in acres, roods, and perches.

The author then describes the method of using the instrument for the solution of questions similar to the following. Knowing the diagonal and the two perpendiculars of a quadrilateral, or the base and perpendicular of a triangle, to determine the areas of the respective figures; the result is known at once in acres, roods, and perches, on inspecting the fourth or fifth circle, according as the area is greater or less than half an acre. The instrument may also be applied to computing square yards; to extracting square roots of numbers; and to the ordinary operations of multiplication and division, in the same manner as other logarithmic lines.

A great advantage of this instrument results from the graduation being on the circumference of a circle. Great enlargement of the divisions is thus obtained, and in a far more convenient form than by drawing a slide, as on the common sliding rule; the diameter of the outer circle in this instrument is sixteen inches. The author considers that a circle of eight inches' diameter would be sufficiently accurate for practical purposes; and such an instrument would be extremely compact and portable.

Teeth of Wheels.

Professor Willis gave a brief account of his investigations on the forms best adapted for the teeth of wheels, and exhibited several models of teeth. The subject might be conceived to be worn almost thread-bare, so much has been written and said about it; and practical men seemed well satisfied with the forms already in use; and the principles on which they were made. These did not, however, appear to him as the best suited to the wants of modern practice. It was a general opinion that only certain curves were adapted for the teeth of wheels—namely, the epicycloidal; he trusted he should be able to shew that there were many others. He believed he had laid down a method of drawing a curve suited to all the wants of modern practice; in general, teeth are epicycloidal with radial straight lines. The consequence is, that a wheel of 50 teeth made in the usual manner to work with one of 30, will not work with one of 60; and to effect any other combination the founder must make a new set of patterns for every new combination, instead of having but one pattern of tooth; and he should endeavour to shew how the epicycloid might be adapted so that the same wheel may drive two or more whose number of teeth is different. Another most important problem was, that having a tooth of any given form to determine a tooth which would work correctly with it.

Such were some of the general features to which his attention had been directed, and the practical method of effecting these objects being fully set forth in his paper, he should merely shew the application as made for the workshop.

March 27, 1838.

The PRESIDENT in the Chair.

The following were duly elected:—G. A. Jermyn, N. Beardmore, as Graduates; Captain R. Dawson, R. E., Henry Handley, M. P., and W. Nicholson, as Associates; Dr. Roget, as an Honorary Member.

The Canal Lifts on the Grand Western Canal. By James Green, M. Inst. C. E.

Green's Canal Lifts.

The Lift which is the subject of the following paper was erected by Mr. Green in the year 1835, on the Grand Western Canal, and has been in operation ever since. Lifts are not intended to supersede the use of canals in all cases, but in those in which a considerable ascent is to be overcome in a short distance, and in which the water is inadequate to the consumption of a common lock, or in which the funds are inadequate to the execution of the work on a scale adapted to such locks.

This Lift is 46 feet in height, and consists of two chambers, similar to those of a common lock, with a pier of masonry between them; each chamber being of sufficient dimensions to admit of a wooden cradle, in which the boat to ascend or descend floats. The cradle being on a level with the pond of the canal, a water-tight gate at the end of the cradle and of the pond of the canal is raised up, and leaves the communication betwixt the water in the canal and in the cradle free, and the boat swims into or out of the cradle.

The cradles are balanced over three cast-iron wheels of 16 feet in diameter, to the centre of one of which is fitted spur and bevil gear, so that the motion may be given by machinery worked by the hand, without any preponderating weight of water in the cradle, when scarcity of water renders this necessary. To this hand gear is also attached brake wheels and a brake lever for regulating the motion. For the details of the construction of this machinery, and of the manner in which the Lifts are worked, reference must be had to the drawings.

It is obvious that the weights of the additional length of the suspending chains on the side of the cradle which is the lowest must be counterbalanced; for this purpose there is attached to the under side of each cradle a chain of equal weight per foot with the suspending chain, and this elongates under the ascending and is shortened under the descending cradle; thus the disparity in the weights due to the suspending chain is obviated.

It is so arranged that the water in the upper cradle is about two inches below the level of the water in the pond; the consequence of which is, that the upper cradle has a slight preponderance first, sufficient to set the machinery in motion; the weight of this water is generally about one ton; it may however be regulated at pleasure.

The strength of materials is the great desideratum in machinery of this nature, and though the Lift here described is but 46 feet, and the boats about 8 tons, the same method is applicable to much greater heights and larger tonnage. The advantages of these Lifts over common locks are great economy of construction, and great saving of time and water.

The time occupied in passing one boat up and another down this Lift of 46 feet is three minutes, whereas thirty minutes would be required to attain the rise of 46 feet by locks; thus the saving in time amounts to $\frac{9}{10}^{\text{ths}}$ for boats of eight tons.

The quantity of water consumed is about two tons for eight tons of cargo, whereas in common locks it is about three tons of water per ton of cargo; the saving is therefore 22 parts out of 24, or very nearly 92 per cent. If the trade were all downward, there would, by the use of these Lifts, be carried from the lowest to the highest level of the canal a quantity of water equal to the loads passed down.

Mr. Green stated, in reply to several questions, that in some parts of the canal it had been found impracticable to get a sufficient drain to empty the chamber—they were compelled therefore to use a half lock of 18 inches' fall; that there were seven lifts and one inclined plane on the canal, effecting a rise of 262 feet in eleven miles. That he should not recommend them as applicable to boats of more than 20 or 30 tons. The width of larger boats was an obstacle. They were extremely advantageous for narrow canals; for boats of 50 or 60 feet in length and about 30 tons.

Mr. Parkes remarked, that he considered the question of narrow canals as a most important one—the advantage to be derived from narrow canals was a subject to which sufficient attention had not been paid.

The President called attention to the remark in Mr. Green's paper respecting the quantity of water carried up from one level to another in a downward trade wherever these Lifts are used; then a coal country on high level may supply itself with as much water as it sends down coal. The subject of inclined planes being alluded to, especially those of the Morristown Canal of 200 feet each, where a rise of 1600 feet is effected by eight inclined planes, Mr. G. remarked that more water and time must be expended, the friction and length being much greater. In the Lifts there was only as much water consumed as was equal to the load, but that he should not consider them as practically applicable to more than 60 or 70 feet. Favourable levels with ascents of more than 60 or 70 feet could seldom be found; could he have had the choice of the line in this particular instance, he should have effected by four lifts the rise for which seven are now employed.

Evaporation of Water.

Some farther observations on the evaporation of water, by Josiah Parkes, were read. The author calls attention to the importance of ascertaining the evaporation of boilers, and of masters having a regular report of the work done, and of the fuel consumed. Attention should also be directed to the settling of the boilers; and their general management. The defects which generally exist are inadequate boiler power, insufficient covering, and absence of good reservoirs. A little attention to these points on the part of respectable engine-makers would lead to definite knowledge, and put an end to the pretensions of the empyric.

The paper is accompanied by a table, shewing the proportionate parts of 112 lbs. of coal burnt in heating water from 32° to 212° with that burnt in evaporating it from 212°. It is constructed on the established principle of the sum of the latent and sensible heat being constant, and is of great use in reducing the results of numerous experiments to one common standard, and ascertaining the value of fuel; and in comparing one set of experiments with another; when the water has been supplied to the boilers at different temperatures.

The evaporation of water as stated by Mr. Manby, in the experiment with Collier's boiler, being reduced to the same standard as others in his paper, it appeared that 20·24 cubic feet were evaporated from 212° F. with 112 lbs. of coal. The quantity evaporated at the Fowey Consols was 21·37 cubic feet.

It appeared on comparing the value of the Locomotive Engine and the Cornish Engine by the quantity of coals consumed, per horse power, they were as 1 to 35.

Heat of Coke and Coal.

The difference in the heating effects of coke and coal having been observed, Mr. Parkes remarked that the heat generated depended on the ratio of the rate of absorption of the oxygen; there must be more space betwixt the bars when coke than when coal is consumed, and the quantity of oxygen required is much greater in the former than in the latter case. More air however may be drawn through the bars than can possibly enter into combustion, and the general temperature is lowered in consequence.

The comparative value of coke and coal in melting glass had been observed by Mr. Pellatt, and it appeared that 21 tons of coke produced the same effect as 26 tons of the best coal.

April 3, 1838.

The PRESIDENT in the Chair.

The following were balloted for and elected; C. R. Buckle, as a Graduate; J. Ignatius Massie, as an Associate.

Teeth of Wheels.

On the Teeth of Wheels. By Robert Willis, Jacksonian Professor of Natural Philosophy in the University of Cambridge.

The geometry of the subject of the teeth of wheels may be considered as complete, but it appears that important additions may be made to its practical applications. The general problem is, having given a tooth of any form to determine one which shall work correctly with it. The method of effecting this may be shewn in a simple practical manner. The curve to be traced out, which is the shape of the required tooth, is the locus of the intersections of all the outlines of the tooth in every one of its positions. The motion produced by the mere contact of the curve so traced out with the given tooth will be uniform. This then is a practical mode of shewing the practicability of the problem.

The epicycloids and involutes have hitherto, from the facility with which they can be described, been almost universally employed, and practice has been confined to the class of epicycloids which work correctly with straight lines or circles. The defect under which such wheels labour is, that a wheel of fifty teeth of the same pitch will not work correctly with a wheel of one hundred teeth of the same pitch; since the diameter of the describing circle by which the epicycloid is formed, must be made equal to the radius of the pitch circle of the wheel with which the teeth are to work, and will therefore be twice as large in the second case as in the first. Also, if the teeth be epicycloids, generated by a circle whose radius is equal to that of the wheel with which it is to work, which is equally correct, the same remark applies.

This defect was of no great consequence when the teeth were wooden, but it is of great consequence in iron wheels, since the founder must have a new pattern of a wheel of forty teeth for every combination that it may be required to make of this wheel with others. It is desirable that the teeth of wheels be formed so that any tooth may work correctly with any other of the same pitch. This is the case with involute teeth, but the obliquity of the action is an objection to their introduction. The requisite property may be given to epicycloidal teeth, by employing the following proposition. If there be two pitch circles touching each other, an epicycloidal tooth formed by causing a given describing circle to roll on the exterior circumference of the first, will work correctly with an interior epicycloid formed by causing the same describing circle to roll on the interior circumference of the second.

From this Professor Willis deduces the corollary, that if for a set of wheels of the same pitch a constant describing circle be taken and employed to trace those portions of the teeth which project beyond each pitch line by rolling on the exterior circumference, and those which lie within it by rolling on its interior circumference, then any two wheels of the set will work correctly together.* This corollary is new, and constitutes the basis of the system already alluded to.

It only remains to settle the diameter of this constant describing circle. The simplest considerations serve to shew that the diameter of the constant describing circle must not be greater than the radius of the pitch circle; hence, as a convenient rule, make its diameter equal to the radius of the least pitch circle of the set. This rule is perfectly general, applying to racks and large wheels, as well as to annular or internal wheels. The simplicity of this above the old system is obvious, for on the old every epicycloid requires two circular templets; also there must be as many templets as pitch circles in the set, whereas on this system but one describing templet is required.

For machinery in which the wheels move constantly in the same direction, the strength of the teeth may be nearly doubled for the same quantity of material, by disposing it so that the backs are an involute or the arc of a circle, the acting faces being of the usual form.

In the preceding the exact forms have been described; the author then proceeds to ascertain forms sufficiently accurate for practice, and which are arcs of circles. Euler suggested the substitution of arcs of circles of curvature instead of the curves themselves. The portion of a curve employed in practice is so small that a circular arc is sufficiently accurate, provided the centre and radius with which it is struck be determined by some more accurate method than by mere trial. With this view Professor Willis was led to investigate a method in which the nature and properties of curves proper for teeth are entirely neglected, and a simple construction shewn by which a pair of centres may be at once assigned for a given pair of wheels, whence arcs may be struck that will answer the purpose of enabling these wheels to work correctly together.

The nature of the motion produced by the pressure of one circular arc against another is then examined and reduced to that of a system of three rods, the middle one of which is jointed to two others, moveable at their other extremity about a fixed centre; and a simple construction is arrived at by which we may always find a pair of centres for which two circular arcs may be struck through any point, which will drive each other truly for a small distance on each side of that point. This point, when the side of a tooth consists only of a single arc, should be on the line of centres. It is however more advantageous that the tooth should consist of two arcs, for then there will be two points at which the action is exact—one a little before reaching the line of centres, the other a little after passing it.

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* For there is both before and after passing the line of centres an exterior epicycloid working with an interior epicycloid; for before passing the line of centres, the part of the driving tooth *within* the pitch line works only with the portion *without* the pitch line of its follower; and after passing the pitch line the part of the driving tooth *without* the pitch line works with some portion of the following tooth which is *within* the pitch line.

From these investigations the author was led to construct an instrument for setting out the teeth of wheels, which may be used with perfect facility by the workmen, and which has been termed an Odontograph; the application of which is fully described. The paper contains many practical observations connected with this subject, tables, &c., and concludes with some directions for ascertaining the correct form of cutters.

On the Ventilation of Tunnels. By W. West.

Ventilation of Tunnels.

This paper contains an account of some experiments on the temperature of the air in a tunnel on the Leeds and Selby Railway. There are three shafts in the tunnel; and he observes, the temperature of the external air being 34°, the temperature at the mouth and as far as the first shaft was 34½°, but that immediately beyond this shaft it rose to 35°, and increased uniformly up to the farther end, at which point it was 57°. From this fact the author infers that the air passed up the shaft, and that the tunnel would be more completely ventilated without any shafts; and that shafts generally are an impediment to perfect ventilation.

Transfer of Letter Bags.

Mr. Carpmael described and illustrated by a model the apparatus invented by Mr. Worsdale for changing the letter bags on the railways without diminishing the speed at which the carriages are travelling. The bag to be taken up is hung on an arm projecting from a post, generally a lamp-post, and the bag to be left is suspended at the end of a rod projecting from the back of the railway carriage. The guard knows the exact distance to which this rod is to be pushed out; and the projecting iron of the lamp post receives the bag to be left at the same instant as a projecting iron on the guard's rod sweeps off the bag to be taken up. This exchange is certain, and effected without any loss of time.

April 10, 1838.

JOSHUA FIELD, V. P., in the Chair.

On the Application of Bickford's Fuzes to Blasting under Water.

By C. W. Pasley, Col. R. E., Hon. M. Inst. C. E.

Blasting under Water.

The improvement in blasting under water, which forms the subject of the above paper, was first adopted at the Royal Engineer Establishment at Chatham, under the direction of the author, in the autumn of 1834.

Great advantage in blasting under water is derived from the use of Bickford's fuzes applied to tin powder cases; also from the new system of tamping by means of small stones, and of fixing ring bolts in stones or rocks, introduced by Mr. Howe. But the ordinary Bickford fuze, though superior to every other in shoal water, cannot be altogether depended on in depths of from five to ten fathoms. The general practice has hitherto been to ignite the powder contained in a tin canister, by dropping a piece of red-hot iron down a tin tube, reaching to the surface. The tin tubes being liable to failures, Colonel Pasley had used flexible leaden pipes, and a piece of portfire instead of red-hot iron for vertical explosions. Several other means of firing—as small rockets, a quick match, and small linen hoses—were tried, but without any great success.

A small fine powder hose, about one-eighth of an inch in diameter, secured so as to burn gradually instead of rushing forward and exploding, was found to succeed very well, but is neither so simple nor so cheap as the Bickford fuzes. These fuzes consist of so minute a thread of fine powder, that they burn rather than explode, and are in no danger of bursting the case, which is made of twisted hemp, coated with pitch, and so performs the double duty both of the hose and the metallic tube. The fuzes having been ignited are thrown on the water, and generate a small column of elastic gas as they burn. Colonel Pasley then details several instances of the successful application of these fuzes, and proceeds to describe the general arrangements which were adopted by him, the fitting up of the tin cases, the mode of firing, the best borers for blasting under water, and a form of plug-bolt peculiarly adapted for mooring and warping up rapids.

The fuze is inserted through the cork of the tin case, upon which is placed an iron cone, having a small groove at the side of the base to admit the fuze, and the hole filled up to the top with small pieces of hard stone of about three quarters of an inch in diameter, as tamping. The plug-bolt, which is 3 feet long and $1\frac{5}{8}$ of an inch in diameter, having about four inches of the bottom end spread out into a cone or base, has about three inches inserted into a hole cut a little oblique towards the current, and fixed in the same manner by pieces of stone.

From experiments on tamping the holes of blasts with loose sand, it appeared that double the charge of powder was required to produce the same effect when the hole was filled with loose sand, as when filled by ramming in fragments of brick; but the method above described is far the most efficacious, saves trouble, and is less liable to accidents.

The Bickford fuzes as ordinarily made were found several times to fail in 10 fathom water, and some larger ones burst the envelope, so that Colonel Pasley is of opinion, that in deep water some other means should be resorted to. Also, when a large quantity of powder is to be fired, the time which the fuze is burning, namely about half an hour in 8 fathom water, keeps the experimenter in a great state of uncertainty as to when the fuze has ceased to burn; the small air bubbles sent up to the surface being generally imperceptible, except at a very small distance. In these cases the small hose and leaden pipe are preferable.

Tamping. The various kinds of tamping employed having been discussed, Mr. Macneill stated that he considered the tamping with sand to consume more powder, but to effect a great saving in time; it was also attended with less danger. He had found considerable advantage result from mixing a small portion of roach lime with the powder.

Colonel Pasley found from his experiments, that tamping with small stones produced the same effect as a double charge of powder, when the tamping was sand. He had also tried equal portions of powder and saw-dust, and the effect of a given quantity of powder in throwing a shell was somewhat increased by the presence of the saw-dust; not however to such an extent as so induce them to trouble themselves with this additional article.

Mr. Rendel considered the best tamping to consist of clay and small stones; any requisite degree of density might be given to such a mass.

April 24, 1838.

JOSHUA FIELD, V. P., in the Chair.

William Rickman and Wilson Saunders were elected Associates.

On Firing Blasts under Water by Galvanism. By John Bethell, Assoc. Inst. C. E.

Firing Blasts by Galvanism

Mr. Bethell's attention was directed to this subject in 1834, when engaged in experiments with his new diving-dresses. It is frequently necessary to blow off the upper decks of a wreck, so as to get at the cargo; but great difficulty has arisen in igniting the powder. A fuze of cotton steeped in spirits of wine and gunpowder and enclosed in a caoutchouc tube was at first used; this, however, being uncertain and expensive, the idea occurred of trying galvanism.

It is well known that when two ends of copper wires leading from the poles of the battery are connected by a piece of platinum, or iron wire, the latter becomes red-hot. To apply this method, the top of the tin canister which contains the charge is fitted with two copper wires, about 6 inches long, passing through a piece of cork, and connected at their lower ends by a piece of platinum or iron wire. The canister being charged, the platinum or iron wire is pushed down into the middle of the charge, and the top of the canister cemented on with putty. The wires are well coated with a non-conducting medium, as a mixture of resin, wax, and tallow, or caoutchouc, excepting at their lower end where they are connected by the platinum, and at the upper where they are to be connected with the two long copper wires which proceed to the battery. These connecting wires, covered with cotton thread, are coated with the caoutchouc varnish, and then tied together so as to form one rope; the diver having connected the wires of this rope with the wires of the canister, and uncoiled a sufficient length of rope, descends and deposits the canister in the wreck or hole prepared for the blast, and returns to the surface. The other ends of the wire are then dipped in the mercury cups of the galvanic battery, and the platinum wire becoming instantly red-hot, the charge is exploded. There is not more than about six inches of the wire rope lost at each discharge.

The security, certainty, and convenience, of this plan are evident. In quarries, any number of charges could be fired at the same instant, or in rapid succession; and this method possesses incalculable advantages over every other for the military engineer, since any number of mines could be exploded at the precise moment that is desired.

On the Limestone, the Lime Cement, and method of Blasting, in the neighbourhood of Plymouth. By W. Stuart, M. Inst. C. E.

Plymouth Limestone.

Plymouth abounds in limestone, which may be raised in solid masses of from three to ten tons; it is used most extensively for building and for lime manure. About 13 cubic feet weigh a ton; the limestone is of a light blue or grey colour, in general free from metallic veins, but with some indications of manganese and ironstone, round pieces of the latter being found in clay beds, intermixed with the rock, and a vein of ironstone four inches thick at the surface of the rock, and dipping towards the south, has been opened.

Cement. The author then proceeds to describe the general method of making cement in that neighbourhood, and the method which he has employed with considerable advantage.

Blasting. The bit or iron rod, called a jumper, is generally used. In pitching a deep hole, a 2-inch bit is used for about four feet, and a $1\frac{7}{8}$-inch for the next four feet, by one man; then two men are employed with $1\frac{3}{4}$-inch to the depth of 14 feet, and $1\frac{5}{8}$-inch to the depth of 21 feet. A constant supply of water is required during boring the hole. The hole being well dried, about one-third is filled with powder, say 15lbs.; a needle is introduced as far as possible without driving it; the hole is tamped with dry clay to the top, and then covered with a little wet clay, to prevent any of the loose particles falling in when the needle is withdrawn. A reed, filled with powder and split at the top, to prevent its falling to the bottom of the hole, is inserted, and a stone laid upon it; the powder being ignited by a piece of touch-paper and a train, the reed flies to the bottom of the hole, and ignites the main load. The rock is generally cracked and loosened to a considerable extent, if not thrown; in that case, the needle is driven through the tamping, and such a fresh charge is run through the needle-hole as may be requisite. From six to eight tons of rock are generally blasted with one cwt. of gunpowder. The paper is accompanied with drawings of the jumpers, the tamping bar, the needle, and the discharging reed.

Account of the Pont-Y-Tu-Prydd, over the Taâf, Glamorganshire. By Thomas M. Smith.

Edwards's Bridge. In 1746, William Edwards undertook to build a bridge over the Taâf; the first, which consisted of three arches, was carried away by a flood; the second, of the same dimensions as the present, fell from the too great load on the haunches. Before commencing the work again, Edwards is said to have consulted Smeaton, and either from the advice of that distinguished man, or from his own experience, he left in each of the haunches three cylindrical openings, from face to face, and it is said that the intermediate spaces are filled up with charcoal. The bridge was finished in 1750. The arch measures 140 feet betwixt the abutments, and has a curved line of 35 feet. The width of the soffit is 15 feet 10 inches at the springing, and 14 feet 5 inches at the crown; the width of the roadway at the crown being 11 feet.

The preceding is accompanied with a beautiful drawing, exhibiting the elevation, plan, and section, of the bridge.

On some Operations in Blasting in the Jumna, and at Delhi.

By George Tremenheere, Lieut. Bengal Engineers, Assoc. Inst. C. E.

Blasting Rock.

In this paper, the author gives an account of the charges of powder, and the mode of tamping in blasting, under his direction during the years 1828 and 1829, for improving the navigation of the Jumna, and from the years 1831 to 1835, at the fortifications of Delhi. The jumpers were 6 feet long, and 2¼ inches in diameter; the blasts 5 feet deep, and at a distance of 4 feet from each other. The rate of boring varied from 2⅓ to 5 feet per day's work for two men. A double-headed jumper was used, to render the hole completely circular for the reception of the canister, about 2½ feet in length and 2 inches in diameter, and filled two-thirds with powder and the rest with sand. The small tube reaching to the surface of the water contained quick-match, with a piece of slow-match at the extremity. The canister, well greased, was placed in the hole without any additional tamping. The method of removing the masses and the tools employed are described and explained by drawings.

At Delhi, the blasting was in dry rock, and economy of gunpowder being of more importance than economy of time, tamping was resorted to. For this a stiff red clay, slightly moistened, was employed, and the tamping bar was of wood, and the priming wire of copper. Any dampness which might exist in the bore was obviated by a tube of coarse paper, greased on the outside. Fine mealed powder was used as priming, and a piece of port-fire for ignition. If the firing did not succeed, a fresh priming hole was bored in the tamping; or the mine abandoned. In large irregular masses of rock, the depth of the bore, or the intervals between the blasts, will generally represent the line of least resistance, and the following results were obtained in the rock at Delhi, which is hard quartz.

The line of least resistance not exceeding one foot, a charge of 2 oz. is sufficient; the line not exceeding 4 feet, and the rock not being highly chrystalline, 3 oz. per foot will be sufficient.

The charges will vary with the tenacity of the rock, but the following may be a general guide :--the line of least resistance being 1, 2, 3, 4, 5, 6 feet, the charge will be 4, 8, 14, 20, 26, 36 ounces.

On comparing the charges used at Delhi, where stiff clay was used as tamping, with those in the Jumna where sand was used, the following table is the result :—

Line of least resistance.	With clay tamping.	With sand.
2 feet	8 oz.	26·8 oz.
2½	10	33·5
3	12	40·2
4	20	53·6

The charges in the last column are to those in the second as 3 to 1, nearly; they are not, however, given as the least required, but are those actually used.

The author is of opinion, that notwithstanding the increased expenditure of gunpowder when sand is used as a substitute for tamping, the saving of time and labour is such as may, under some circumstances, counterbalance that disadvantage. This is stated to have occurred on the Jumna, where, owing to the rise of the river during the periodical rains, it was required to execute the greatest possible quantity of work with large bodies of men in a given time.

May 1, 1838.

JOSHUA FIELD, V. P., in the Chair.

Peter Rothwell was elected a Member; Sir George Cayley, Bart. and James G. Marshall were elected Associates.

On Huddart's Rope Manufacture. By George Drysdale Dempsey.

Huddart's Rope Machinery.

The above communication on the improvements in rope manufacture, introduced by the late Captain Huddart, contains a general account of the successive improvements introduced, and a description of the machinery invented by that celebrated man and erected at Limehouse.

It is accompanied by ten sheets of drawings of the machinery.

The preceding communication having been laid before the meeting, a discussion took place on the relative strength of the cables of Huddart's and the ordinary manufacture. The strength of two-inch rope of Huddart's, when compared with that of the ordinary manufacture, is as 8 to 5½. The increase in strength was greater for large ropes than for small. The best test of the wear of ropes are those of mines. A five-inch Huddart's rope has been found to last twice as long as a six-inch rope; the weight of the former is much less, consequently there is a great saving in power as well as in durability. It was stated that there was danger of the tar being of such a temperature as to char the yarns; tar of the temperature of boiling water was the best.

May 8, 1838.

The PRESIDENT in the Chair.

George Tremenheere, Lieut. Bengal Engineers, and W. S. Inman, were elected Associates; and Professor Willis, an Honorary Member.

On Huddart's Rope Machinery. By E. Birch.

Huddart's Rope Machinery.

In this communication the author has described the general mode of manufacture, prior to the improvements introduced by Captain Huddart, and the establishment of the works at Limehouse.

It is accompanied by fifteen sheets of drawings of the machinery.

"On the relative Heating Powers of Coke and Coal in Melting Glass." By Apsley Pellatt, Assoc. Inst. C. E.

Heating Power of Coke and Coal.

The object of this paper is to confirm some statements of Mr. Parkes,* as to the calorific power of coke and coal from experience of the author's in melting glass. The great loss of heat arising from the flame and unconsumed gaseous portions of the fuel being driven up the flues, when the furnaces are heated by coal, and the fact that coke succeeds better than coal in annealling glass, determined the author to persevere for a month in heating the furnaces with coke, and to compare the result with those obtained when the best coal was employed.

The construction of the furnace and the arrangement of the pots and flues are described. The furnace is somewhat reverberatory, being between an air furnace and an oven; the smoke and flame not escaping at the top, but being drawn to flues betwixt the pots, which are set round in a circle. For the purpose of obtaining sufficient heat about the points and sides of the pots, there are small holes, called "bye-holes," through which the flames should play outward in a length of 5 or 8 inches. The healthful action of the furnace is indicated by the length of the flame issuing from the bye-holes and tops of the flues. Great care is requisite in regulating the supply of air, too much air endangering the pots, too little checking the heat of the furnace. The bars were obliged to be placed at 2 inches apart instead of 1½; the greater concentrated heat of the coke not only requiring more air, but having a tendency to melt the bars; lumps of fire-brick also were thrown in to supply the deficiency of clinkers. To make, however, the flues and bye-holes draw well, it was necessary to use ⅕th of screened coals with ⅘ths of good coke, by measure. The following is the result:—For nine months the consumption of coals for a 7 pot furnace was 18 tons per week. For four months, on the new system, the consumption was 10½ tons of coke, and 5 tons of screened coals per week. Deducting then these 5 tons, it appears that 10½ tons of coke are of the same value as 13 tons of coal, or there is a saving of near 20 per cent. in the weight of fuel, and a superiority of 25 per cent. in the heating power of coke above that of coal. Considerable advantage is also derived from the saving of the pots and in other incidents peculiar to the manufacture of glass.

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* See *Minutes*, p. 19, March 6, Session 1838.

Mr. Parkes observed that the preceding statements had more than confirmed his results. From the statements of Mr. Pambour, on whose data his calculations had been founded, it appeared that gas coke was inferior to Worsley coke by 12½ per cent.; in his reasonings he had allowed 20 per cent. as the difference betwixt good coke and coal; but according to the results given by Mr. Pellatt, that allowance ought to be 32½ per cent. He was of opinion that the advantage to be ascribed to the screenings was part chemical and part mechanical. The coal would fill up the interstices of the coke, and prevent the air from escaping unconsumed.

Mr. Pellatt remarked, that the safety of the pots was a very important consideration. By the terms hard and soft coke, he understood foundry and gas coke; the former gave a much more intense heat, and lasted longer. The coke he had used was gas coke, and about 14 cwt. to the chaldron. Mr. Fox stated that the coke in use on the London and Birmingham Railway is about the same weight. It was stated that coal which lost ¼th in weight gained ¼th in bulk by coking.

May 15, 1838.

JOSHUA FIELD, V. P., in the Chair.

The following were elected: John Hague, a Member; Thomas Turner, a Graduate; and Lieutenant Frome, R.E. an Associate.

Thames Tunnel.

Mr. Brunel stated that they were at present more inconvenienced by fire than by water. Some of the gases which issue forth ignite very rapidly; and the reports from Guy's Hospital stated some of the men to be so injured by breathing these gases that small hopes were entertained of their recovery. The explosions are frequent, and put out the candles of the workmen; but the largeness of the space prevents their being dangerous. The thickness of made ground above them is about 18 feet. He conceives that these deleterious gases issue from the mud of the river; they proceed from a corner at the top. They had used chloride of lime, but without any great success; there appeared no remedy for the inconvenience. The breathing the gas produces sickness.

Explosion of Steam Boilers.

A communication was read from Mr. Timperley, of Hull, on the explosion of the boiler of the Union Steam Packet at that place last summer. This was attributed to the water in the boiler having become so far reduced as to lay bare the tops of the flues, which would probably be heated to a very high temperature. Water coming in contact with them in this state, on a slight lateral motion of the vessel, steam of sufficient intensity to produce the effects described might be produced.

Mr. Macneill stated that the boiler plates had in the above instance been rent across like a sheet of paper. There was not a single rivet broken.

A long discussion took place on the causes to which these extraordinary cases could be referred: the violence of the explosion on bursting appearing greater than could be referred simply to the pressure of the steam. If the water were supposed to be decomposed by contact with the hot plates, some of the oxygen would be absorbed by the metal, and the proportion requisite for an explosive mixture destroyed. But there were great difficulties in conceiving the decomposition of water by the plates of a boiler. The commission of the Franklin Institute concluded this to be impossible.*

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* See Report of Franklin Institute on the Explosion of Steam Boilers.

It appeared then that there were grounds for doubting the fact of the presence of oxygen, such as would cause an explosion. And it seemed almost unnecessary to resort to any such explanation, as the sudden generation of steam of high elasticity would produce a pressure sufficient to blow out or rend the boiler in the weakest part before the pressure could be transmitted through the steam to the safety valve. The transmission of pressure through an elastic fluid requires time, but the action on the solid is instantaneous.

"Steam Expansion Table. By George Edwards, M. Inst. C. E."

Edwards's Expansion Tubes.

A paper by Mr. Edwards was read descriptive of the principle and method employed in dividing his Steam Expansion Table, an account of which had been laid before the Institution last session.

May 22, 1838.

The **PRESIDENT** in the Chair.

Bursting of Steam Boilers.

The minutes of conversation on the Explosion of Steam Boilers having been read, considerable doubts were expressed as to the probability of the formation of an explosion under the circumstances in the interior of a boiler. It was suggested whether a large portion of hot surface might not become suddenly exposed by the cracking off of the incrustation on the sides of the boiler. The metal expands more rapidly than the incrustation; portions of the latter may crack off and expose a large extent of hot surface to the steam and water; a sudden increase in the elastic force of the steam would necessarily ensue. The incrustation is itself a bad conductor of heat.

Mr. Field, in reply to a question respecting the rapid decay of the bottoms of copper boilers, stated, that copper is very rapidly injured by repeated heatings, and will not long bear high degrees of temperature.

Mr. Cubitt stated that he had not known of any case of explosion of a boiler containing plenty of water. With respect to a recent accident in America, which had taken place soon after the boat had started, he thought that a boiler was more likely to be short of water at starting than at any other time, for the steam will probably have been blowing off for some time, and the men neglected to supply the boiler; whereas after the vessel has started, the pumps worked by the engine supply the boiler. He should think that a boiler is more likely to be short of water before or just after starting, than at any other time.

Mr. Field stated that the vessel had stopped, and the explosion took place while taking up a passenger; the safety valve had been held down. In all these cases of explosion the difficulty which he experienced was, how to account for the pressure being suddenly increased by the amount which must be supposed. It did not appear to him sufficient to suppose that water flowed over hot flues. If the whole of the top of the fire-place were red hot this could not produce the effect. The steam boilers in America are generally of a form ill adapted to resist pressure.

Mr. Buddle stated the only clearly ascertained fact seemed to be that these explosions took place when the boilers are dry. He had a case of twin boilers, standing side by side; the dry one exploded; no cause could possibly be assigned but that it was dry. The steam communication betwixt the boilers was free, by a pipe *eight* inches diameter. It was not a collapse, but the boiler was torn into a thousand pieces. There are two distinct cases; the one a rent or bursting, the other an explosion, in which the parts are thrown to a considerable distance.

Mr. Cubitt called attention to the remarkable case mentioned by Mr. Buddle of two boilers connected together by a steam pipe of eight inches diameter, the communication free betwixt them, but one short of water; the other having its proper quantity of water. The dry boiler blew up with a great explosion, the other remaining uninjured. The steam was blowing off at the time. With respect to the nature of the report, Mr. Buddle stated that he had not himself heard it, but it was represented as sudden and short; any representation of this nature cannot be depended on, as two persons situated in different positions will give very different accounts. This had occurred to his knowledge on the explosion of a coal mine. He was close by and thrown down; the report was smart like that of a six-pounder; at two miles off it was like a peel of thunder, shaking the houses and throwing down the furniture. One peculiar feature in the explosion of the steam boilers is the rending and crumpling up of the boiler plates. The plates are rent and twisted as if of paper.

"History and Construction of Westminster Bridge, accompanied with detailed Drawings. By F. Whishaw, M. Inst. C. E."

Westminster Bridge

This account of Westminster Bridge has been extracted from the very voluminous documents in the Westminster Bridge Office, access to which was given to the author of this paper by the kindness of Mr. Swinburne, the resident engineer to the Bridge.

The first act was passed in 1736, and empowered certain Commissioners to raise moneys by lottery. Three sites were pitched upon; the Horse-ferry, over against the Palace Yard, and over against the Woolstaple, which latter was finally fixed on. The scheme was violently opposed by the City of London and the Thames watermen. The Commissioners selected a very curious and well-designed wooden superstructure, by James King, but having determined that the bridge should be of stone, they accepted a proposal from Mr. Labelye to found one pier by means of caissons, and which he had offered to build at his own expense.

This bridge, so lasting a monument to the genius of Labelye, consists of fifteen semicircular arches, decreasing regularly in span by 4 feet from the centre, which measures 76 feet, to the sixth arch on each side, which is 52 feet in span; all the arches spring from the line of low water of 1736. The whole distance between the abutments is 1068 feet, with 870 feet clear water-way, and 198 feet solid. A peculiar feature in this bridge is, that the spandils are formed of radiated purbeck blocks with occasional bond stones, and the interior filled with ballast and rubbish.

The design of Mr. Labelye was the only one for laying the foundations of the piers under water, and the application of caissons for this purpose then first took place. The construction of these caissons and method of founding the piers by means thereof are fully described and illustrated. The piles were driven by an engine invented by Mr. Valoue, a watch-maker; it was erected on a platform, fixed on the top of a barge, and worked by three horses walking round and turning an upright shaft, on which was fixed a large cog-wheel and a drum, on which the rope was wound, and passing by pulleys to the top of the guide frames was connected with a follower furnished with tongs, as in the common pile engine. The number of strokes in an hour was about 150, at an elevation of 9 feet; the weight of the ram 1700 lbs. The piles were generally cut off; the time occupied in cutting off a pile about 15 inches square and 10 feet under water being not more than a minute and a half. The construction of the abutments and of the arches is fully described, and the quantity of stone employed in the middle

76-foot arch, and the two adjoining 72-foot, is stated; the expense of these three arches was £24,074.

The centres employed were on the principle of the diagonal truss; for the five middle arches three rows of piles were driven on each side to support the centres, and for the other arches only two rows. Each centre consisted of five ribs of fir timber, resting on transverse and longitudinal oaken plates. The five centres used on the Westminster side were afterwards used for the corresponding arches on the Surrey side; the striking of the centres was first performed by means of circular wedges of a peculiar construction; this mode however, from its expense, was superseded by straight wedges.

A most interesting portion of the history is that which relates to the 15-feet sunken pier. There was no piling under the caisson bottoms, and the removal of gravel of the bed of the river very near the pier in question occasioned consequently a sinking. The progress and nature of the sinking are accurately detailed. The south point had settled 14 inches and the north point 13 inches; and the sinking still going on, it was determined to remove the superstructure above the sunken pier and damaged arches; the sinking still continued, but at last appeared to stop, and the whole amount was found to be 3 feet 4 inches at the north-west angle, and 2 feet 7 inches at the south-east angle, of the pier. Centres were erected under the two damaged arches; the adoption of which plan was recommended to the Commissioners in the following words: "If the pier should settle much more it is not in the power of any mortal agent or agents to hinder the arches from following it, as long as it is possible; and therefore, in that case, the two arches instead of parting asunder, and their materials falling into the river, and not to be taken up without a great expense of time and money, will be received and their materials supported and secured, in order to their being regularly unbuilt." The pier, however, lightened as above described, did not continue to sink, and the weight over the piers was considerably reduced by introducing segment arches over the 15-foot pier, and half arches over the adjoining piers, leaving a considerable void space beneath each.

Labelye presented to the Commissioners several reports on the open joints, on the sunken pier, on the Surrey New Road, and on the completion of the works. These are most interesting, serving, as they do, to exhibit the state of engineering at that time in the country.

A detailed account is also given of the ingenious wooden superstructure designed by Mr. James King, and of Mr. Batty Langley's design for a wooden bridge at the Horse-ferry. The author has also collected, at immense pains, the prices of materials and of labour as paid in the erection of Westminster Bridge; he has also compiled a journal of works from the commencement of the undertaking to the time the bridge was opened. These most interesting and instructive documents are collected from the voluminous records deposited in the Bridge Office.

The paper is accompanied by an atlas of eleven drawings, shewing the site and all the details of the bridge, with fac-simile signatures of Charles Labelye the engineer, and Messrs. Jelfe and Tufnell the contractors.

May 29, 1838.

The PRESIDENT in the Chair.

James Routh and B. Townshend were elected Graduates; and F. Braithwaite, J. Milner, N. King, J. Richards, P. Henderson, were elected Associates.

Decomposition of Water.

The minutes of the conversation on the explosion of Steam Boilers were read, and Mr. Lowe stated that the ordinary process of making water gas shewed that an iron plate would readily decompose steam or water. The decomposition of water goes on extremely well until the oxidation of the tube has advanced to at least $\frac{3}{16}$ths of an inch. An iron tube begins to make gas extremely fast at first, and continues until the tube is cased with a thick crust of protoxide of iron.

Thames Tunnel.

The drawings of the Shield at the Tunnel were exhibited, and Mr. Brunel explained the construction of the Shield, and the manner in which it is advanced and worked.

June 12, 1838.

The PRESIDENT in the Chair.

Captain Robe, R.E. and James Thomson, were elected Associates.

Mr. Bruff exhibited an improved form of Levelling Staff. The figures on this staff are inverted, so that when viewed by an inverting telescope in the usual manner, they appear erect, and are read off without any danger of mistake; which may readily occur when some figures, as for instance 6 and 9, are read off inverted. The mechanical arrangements for extending it are with the view of securing greater steadiness. The principal improvement consists in there being attached to the bottom an universal joint, fixed to an iron plate; this plate remaining fixed, the necessary errors consequent on moving the staff for reversing its face, when the last forward station is to become the next back, are avoided.

Improved Levelling Staff.

It was suggested that the universal joint would be attended with great advantages in sloping ground; in general, however, the tripod invented by Mr. Simms was sufficiently convenient.

Mr. Bald suggested that the universal joint would be extremely serviceable if placed on something solid. It was his practice to drive a wooden plug into the ground, on which the staff was set; these plugs were left in, and serviceable for verifying the observations. He had levelled through a distance of forty miles, leaving a plug at every station.

"Description and Drawing of the Ice Boat. By S. Ballard, A. Inst. C. E."

Ice Boat.

The principle of breaking ice adopted by Mr. Ballard, as explained in a communication made last Session,* consists in forcing the ice upwards instead of forcing through it horizontally, or by pressing it down. For this purpose a frame, coated with sheet iron, is laid over the front of a boat, with an inclination downward from the boat, the lower end being under the ice. The paper describes the construction of the boat by reference to a detailed drawing and section.

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* See *Minutes of Proceedings*, Jan. 31, 1837.

"Experiments on the Flow of Water through pipes of different lengths. By W. A. Provis, M. Inst. C. E."

Flow of Water through Pipes.

In this paper are recorded ***two hundred and eight*** experiments on the flow of water through leaden pipes of 1½ inch diameter, of lengths 100, 80, 60, and 40 feet, and for heads of water of 35, 30, 24, 18, 12, and 6 inches. The arrangement of the experiments is described with great accuracy, and the results of the experiments are given in twelve tables, shewing the length and inclination of the pipe, the head of water at the upper end of the pipe, the time from turning the water into the upper end of the pipe to its reaching the lower end, the time of filling the receiver, the discharge in cubic feet per minute, and the mean discharge per minute. To each set of experiments is appended a column of remarks, in which the state of the pipe as to dryness, and the quantity of water in the discharging end, are recorded; these circumstances having considerable influence on the quantity of the discharge.

The experiments are tabulated in a different form, shewing the effect of a given head of water in pipes of different lengths and inclinations. The following important results are deduced. In level pipes the quantity of water discharged is nearly in the inverse ratio of the square root of the length; but the departure from this rule is greatest in the shortest lengths and greatest heads. In inclined pipes, the increased discharge is greater in the long than in the short pipes. The increased discharge for an increased head is nearly in the same proportion through the long and short lengths.

June 19, 1838.

The **PRESIDENT** in the Chair.

"Table of Gradients. By C. Bourns, A. Inst. C. E."

Gradients.

TABLE OF GRADIENTS.

						per chain.							*per chain.*
1 ft.	per mile	=	1 in	5280	=	.15 of an inch	31 ft.	per mile	=	1 in	170.3	=	4.65 of an inch
2	"	=	"	2640	=	.30 "	32	"	=	"	165.0	=	4.80 "
3	"	=	"	1760	=	.45 "	33	"	=	"	160.0	=	4.95 "
4	"	=	"	1320	=	.60 "	34	"	=	"	155.3	=	5.10 "
5	"	=	"	1056	=	.76 "	35	"	=	"	150.8	=	5.25 "
6	"	=	"	880	=	.90 "	36	"	=	"	146.6	=	5.40 "
7	"	=	"	754.2	=	1.05 "	37	"	=	"	142.7	=	5.55 "
8	"	=	"	660.0	=	1.20 "	38	"	=	"	138.9	=	5.70 "
9	"	=	"	586.6	=	1.35 "	39	"	=	"	135.4	=	5.85 "
10	"	=	"	528.0	=	1.50 "	40	"	=	"	132.0	=	6.00 "
11	"	=	"	480.0	=	1.65 "	41	"	=	"	128.8	=	6.15 "
12	"	=	"	440.0	=	1.80 "	42	"	=	"	125.7	=	6.30 "
13	"	=	"	406.1	=	1.95 "	43	"	=	"	122.8	=	6.45 "
14	"	=	"	377.1	=	2.10 "	44	"	=	"	120.0	=	6.60 "
15	"	=	"	352.0	=	2.25 "	45	"	=	"	117.3	=	6.75 "
16	"	=	"	330.0	=	2.40 "	46	"	=	"	114.8	=	6.90 "
17	"	=	"	310.6	=	2.55 "	47	"	=	"	112.3	=	7.05 "
18	"	=	"	293.3	=	2.70 "	48	"	=	"	110.0	=	7.20 "
19	"	=	"	277.9	=	2.85 "	49	"	=	"	107.7	=	7.35 "
20	"	=	"	264.0	=	3.00 "	50	"	=	"	105.6	=	7.50 "
21	"	=	"	251.4	=	3.15 "	51	"	=	"	103.5	=	7.65 "
22	"	=	"	240.0	=	3.30 "	52	"	=	"	101.5	=	7.80 "
23	"	=	"	229.5	=	3.45 "	53	"	=	"	99.6	=	7.95 "
24	"	=	"	220.0	=	3.60 "	54	"	=	"	97.8	=	8.10 "
25	"	=	"	211.2	=	3.75 "	55	"	=	"	96.0	=	8.25 "
26	"	=	"	203.1	=	3.90 "	56	"	=	"	94.3	=	8.40 "
27	"	=	"	195.5	=	4.05 "	57	"	=	"	92.6	=	8.55 "
28	"	=	"	188.6	=	4.20 "	58	"	=	"	91.0	=	8.70 "
29	"	=	"	182.1	=	4.35 "	59	"	=	"	89.5	=	8.85 "
30	"	=	"	176.0	=	4.50 "	60	"	=	"	88.0	=	9.00 "

" On the construction of Roads on Deep Bogs and Moss. By W. Bald."

Roads over Bogs. In this paper the author gives a detailed account of the construction of Roads through Bogs, and of the methods of securing the foundations of small bridges in boggy places; also some suggestions on the formation of Railways on deep Moss.

The general principles are as follow. The first operation after laying out the line of road is to drain thoroughly the bog over which it is to pass. For this purpose main drains and counter drains parallel to the line of road are to be cut with a regular discharging fall along the bottom. Transverse drains must also be cut betwixt the main and the counter drains, so as effectually to drain off all the surface water and stagnant pools. The cutting of these drains must be carried on gradually, and by degrees; if the bog be moist, the operations, which can only be carried on at dry seasons of the year, will probably have to be continued over three or four years before the drains become permanently fixed at the required dimensions. The counter drains are essential, as they relieve the pressure on the sides of the main drain, and consequently prevent it filling up. The bog stuff cut out is to be dried, and when the bog under the line of road has become sufficiently dry, the road is to be levelled, and made of proper shape, and the cross drains are to be filled with dry turf.

The road-way is then to be floored or trunked over with five courses of dry heathy sods, which are to be well rolled with a heavy cylinder. Upon this trunking is to be laid a soling, consisting of a mixed mass of prepared earth and gravel, of about six inches in thickness, and the whole to be coated with good clean gravel. The road metal is then to be laid on, in two successive coats, each of about three inches in thickness, the first being well consolidated before the second is laid on.

The great points to be aimed at are perfect drainage and good trunking, as, if these are not attained, roads constructed on bog will lose their shape, become ruinous, and soon go to decay.

Size of hammers. The author considers the form and size of hammers employed in breaking hard stones.

These are frequently too heavy; a hammer weighing about a pound and a quarter, of an elliptical form, pointed at the ends, the area of end being about $\frac{1}{100}$th part of a square inch, appears to be best suited for ordinary purposes.

Turf Fuel. The turf of bog, being carbonized, makes excellent fuel, and may be employed in the manufacture of iron, and such iron is extremely malleable. Turf fuel is also used most extensively in working the steam engine in many districts of Ireland; it is used on board the Dunally steam boat, for engines of eighteen horse power, and the expense is fourpence per mile.

June 26, 1838.

The PRESIDENT in the Chair.

Sir John F. W. Herschel, Dr. Faraday, and J. G. Children, Esq., were elected Honorary Members.

Hardening Iron.

A discussion took place on the effect of turf fuel on iron, and on the methods and principles of hardening iron.

Tubing Locomotive Boilers.

A communication was read from Mr. Buck on the relation betwixt the diameter and intermediate spaces of the tubes in a locomotive boiler, for the production of an unanimous effect in the generation of steam.

Telford Premiums.

The following notice of subjects for TELFORD Premiums was read: The COUNCIL of the Institution of Civil Engineers give notice that they will award, during the ensuing Session, Telford Premiums to communications of adequate merit on the following subjects:—

1. The Nature and Properties of Steam, especially with reference to the quantity of Water in a given bulk of Steam in free communication with water at different temperatures, as deduced from actual experiment.
2. The Warming and Ventilating Public Buildings and Apartments, with an account of the methods which have been most successfully employed for ensuring a healthy state of the atmosphere.
3. An Account and Drawings of the original construction and present state of the Plymouth Breakwater.
4. The ratio, from actual experiment, of the Velocity, Load, and Power, of Locomotive Engines on Railways.
    - 1st. Upon Levels.
    - 2nd. Upon Inclined Planes.
5. The Sewage of Westminster.

6. Drawings and Description of the Outfall of the King's Scholar's Pond Sewer, and of other principal Outfalls of the Westminster Sewage; also, the inclination, dimensions, and forms, of the Sewers, and the observed velocities of water in them.
7. Drawings and Descriptions of the Sewage under the Commission for Regent Street, especially of the Outfall at Scotland Yard.
8. Drawings and Description of the best Machine for describing the profile of a Road, and also for measuring the traction of different roads.
9. The alterations and improvements in Blackfriars Bridge.
10. The explosion of Steam Boilers.—Especially a record of facts connected with any explosions which have taken place: also, a description, drawings, and details, of the Boiler, both before and after the explosion.
11. Drawings, Sections, and Descriptions, of Iron Steam Vessels.
12. The comparative advantages of Iron and Wood as employed in the construction of Steam Vessels.
13. The advantages and disadvantages of the Hot and Cold Blast in the manufacture of Iron, with statements of the quality and quantity of the materials employed, and produce thereof.
14. The causes of and means of preventing the changes in texture and composition which Cast Iron occasionally undergoes when in continued contact with Sea Water.
15. The Properties and Chemical Constitution of the various kinds of Coal.

The communications must be forwarded to the house of the Institution,* on or before the 30th of March, 1839.

It is not the wish of the Council to confine the Telford Premiums to communications on the above subjects; other communications of distinguished merit and peculiarly deserving some mark of distinction will be rewarded.

Lists of these subjects, and any farther information, may be obtained on application to the Secretary.

THOMAS WEBSTER, *Secretary.*

July 9, 1838.

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* All communications previous to the 25th of December, 1838, to be addressed to Cannon Row, Westminster; after this, to No. 25, Great George Street, Westminster.

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INSTITUTION

OF

CIVIL ENGINEERS.

MINUTES OF PROCEEDINGS,

SESSION 1839.

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The Institution is not, as a body, responsible for the facts and opinions advanced in the following abstracts of the papers read, and of the conversations which took place at the Meetings of the last Session.

INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1839.

ANNUAL REPORT.

Annual Report.

It is with feelings of the greatest satisfaction that the Council invite the attention of this Meeting to the following Report, the presentation of which terminates the trust confided to them by the last Annual General Meeting.

The twentieth year of the proceedings of the Institution has been marked by events of considerable importance, furnishing the strongest evidence of the steady progress and success which have attended the labours of the Council, aided as they have been by the unanimous co-operation of the general body. To meet on the present occasion under circumstances more favourable than perhaps attend any similar society, is most gratifying;—but the gratification stops not here: to form a proper estimate of your present condition, it is necessary to contrast that of earlier years with the steadily increasing progress of the last. In fulfilling the more extensive duties consequent on this progress, as well as on the many important changes which have taken place, the Council have always been deeply sensible of the high responsibility committed to them, and that their endeavours have been well directed, will, they trust, be apparent from the present report; to the details of which they now solicit your careful attention.

New Premises.

The hopes which were at the last Annual Meeting held out respecting the present premises, have been more than fully realized. The kindness of the Commissioners of Compensation in resigning at Midsummer that portion of the premises in which the more important alterations were to be made, has enabled the Council to commence the Session in the present place; and though the repairs be yet incomplete, the Council believe they will be completed ere the Institution again meets. The alterations and repairs will be executed for about £1000. More than £700. have been already subscribed, and among the many gratifying circumstances of the past year, the Council would particularly select the liberality with which all have come forward to further this object.

Such has been the unanimity of feeling evinced in this respect, that the Council believe ample resources will be found, and that the future Council will not have to avail themselves of the liberal offer of your President, to advance whatever sum the Institution might require.

The existing furniture is all available for the present premises, and the outlay which will be required for what more may be desirable for your comfort and suitable accommodation, will not be greater than the growing resources of the Institution can conveniently meet; so that there is no danger of any permanent debt being entailed on the funds of the Institution. By the terms of the lease you are secured from the expense of serious repairs, and from the completeness with which, on the present contract, they will be executed, the Council do not anticipate that any thing further of importance will be required for many years to come.

Bye-Laws. The Council would next advert to other subjects which have occupied their attention during the past year, some of which were dwelt upon at length in the last Annual Report. It will be in the remembrance of most that, during the year preceding the last Annual Meeting, some changes were made in the constitution of the general body and of the Council. The more important of these changes were, the incorporation into the class of Members, without distinction of residence, of all those whose professional qualifications were recognised as the same; the creation of a new class under the term Graduates, to include those who, either as pupils or assistants to Engineers, were qualifying themselves for the practice of the profession on their own account; the increase of the number of the Council, and the addition of two as representatives of the class of Associates. The Council, on the experience of the past year, conceive that these and other important changes recommended by their predecessors in office, and adopted by the General Meeting of Members, have contributed much towards the success and permanent stability of the Institution.

The Council conceive that the introduction of two from the class of Associates may be attended with great benefits to the Institution. This change has been objected to by some zealous friends of the Institution among the Associates themselves, on the ground that such an introduction might tend to divert the attention of the Institution from objects strictly professional. The Council, however, do not conceive that such fears have any just foundation, so long as the rest of their body consists of men honoured by the confidence of the profession; but, on the contrary, that the class of Associates, containing many distinguished for their attainments in pursuits intimately connected with the practice of the Civil Engineer, will furnish those who may co-operate in advancing not only the interests of the Institution, but the cause of general knowledge. The Council cannot omit to bear testimony to the valuable services of Mr. Carpmael and Lieutenant Denison during the preceding year, and they would repeat the recommendation made to the last Annual Meeting, that two of the class of Associates be elected on the Council of the ensuing year.

Other alterations have been suggested, on which the Council have bestowed much deliberation, and in case the future Council should think it advisable to summon a General Meeting of Members, to consider the propriety of making any alteration in the existing laws, it may be advantageous briefly to advert to one or two of the proposed alterations, which have occupied the attention of the Council during the past year. It has been suggested that the Annual Election of the Council should be conducted in a somewhat different manner from that at present pursued: That a greater number than that constituting the Council should be nominated, and that each person at the Annual General Meeting, instead of, as at present, erasing one name and substituting another, erase as many names as the number on the Balloting list exceeds the constituted number of the Council. It has also been suggested, whether it may not be for the advantage of the Institution, that the Council should be increased by the addition of two Members; that, as frequently some of its most distinguished Members are inevitably prevented by professional engagements from attending the ordinary meetings, the Council should be enlarged to as great an extent as may be consistent with the true interests of the Institution.

The Council have frequently experienced difficulty in deciding on the qualifications for admission into the class of Members. It is a peculiar feature in your Institution, that the class of Members should consist of those strictly engaged in the practice of the Civil Engineer. The objects of the Civil Engineer are defined by your Charter, and the Council, considering that the success and permanency of the Institution must depend in a great measure on the care exercised in admission into this class, have repeatedly considered this subject with the view of presenting some definite rules for the guidance of themselves and others. It has appeared that they will be Members.

aided in this difficult task by adhering as much as possible to the two following conditions:—either

> He shall have been regularly educated as a Civil Engineer, according to the usual routine of Pupilage, and have had subsequent employment for at least five years in responsible situations, as resident or otherwise, in some of the branches defined by the Charter, as constituting the profession of a Civil Engineer:—or,
>
> He shall have practised on his own account in the profession of a Civil Engineer for five years, and have acquired considerable eminence therein.

It is thought that the first condition will include those who, by regular education, have done their utmost towards qualifying themselves for the profession, and that their subsequent employment in responsible situations will be a guarantee that they have availed themselves of the opportunities which they may have enjoyed.

In the earlier days of the science of the Civil Engineer, such a condition would have been inapplicable; then the force of native genius sufficed to place the individual in that position of professional eminence, which commenced with a Brindley and a Smeaton, and was in our own time exemplified in a Rennie and a Telford. To such, of whom there are many illustrious examples amongst us, the second condition is strictly applicable.

Transactions.

Since the close of the last Session, the second volume of the Transactions has been published. The Council regret that the volume should have been delayed so long beyond the expected time, but they would remind the Meeting that the preparation of a volume, containing twenty-three highly executed plates, is a work of no ordinary difficulty, and that a delay in any part will of necessity preclude the publication of the volume. The danger of delay, when a whole volume is to be published at once, has led the Council to consider, whether it would not be for the interest of the Institution, to publish in parts of volumes, and, from time to time, as they can be prepared, such communications as are destined to occupy a place in the Transactions. The advantages resulting to all parties from such an arrangement would, it is conceived, be great; delay in the publication of a body of communications by reason of the incompleteness of one of them, would be entirely avoided; authors would surely gladly avail themselves of this means of transmitting papers to the world, since all the merit due to priority of claim would then be undoubtedly secured to them.

Minutes of Proceedings.

Should, however, the succeeding Council consider the propriety of adopting some plan similar to the above for the publication of the Transactions, the Council would urge the importance of adhering to the publication of the Minutes of Proceedings. In these are recorded many communications of partial and transient interest which would be comparatively of little value unless published at the time. By these, the public is at once brought into immediate contact with the Institution; the labours of Authors can be extensively made known; their merit in the priority of invention and discovery secured as a matter of history, and their opinions canvassed almost as soon as promulgated by many competent judges who are unable to attend the Meetings.

Telford Premiums.

At the close of the preceding Session, the Council issued a list of subjects, to adequate communications on which they would award Telford Premiums. The following communications were received: A most elaborate and beautiful set of drawings of the Shield at the Thames Tunnel from Mr. Brunel, and two sets of drawings of Huddart's Rope Machinery, the one from Mr. Birch, the other from Mr. Dempsey. The merits of this celebrated Shield and its value as a means of executing works similar to the Thames Tunnel are so well known, that it were superfluous here to insist upon the benefits which Mr. Brunel has, by the invention of it, conferred on the Civil Engineer. The Council, feeling that this communication and the invention of the Shield were entitled to a high mark of approbation, determined on presenting Mr. Brunel with a Silver Medal, accompanied by a suitable record of the sense entertained of the benefit conferred by him on the practice of the Civil Engineer. Feeling also that the beauty of the Drawings fully merited some mark of approbation, they determined on presenting the draughtsman, Mr. Pinchback, with a Bronze Medal in testimony thereof.

The communications by Mr. Birch and Mr. Dempsey on Huddart's Rope Machinery, likewise called for some special mark of approbation on the part of the Council. The liberality of Mr. Cotton, the intimate friend of the late Captain Huddart, and proprietor of this machinery, in throwing open to the Institution the works at Limehouse, is fresh in the recollection of most present; with that same liberality he at once acceded to the wish of the Council to allow any person to attend and make drawings of this celebrated Rope Machinery for the Institution. Two young men availed themselves of this liberality, and with great perseverance measured and took drawings of this elaborate machinery, and the results of their industry are the two beautiful sets of drawings, accompanied by suitable manuscript accounts, presented by them to the Institution. Of the accuracy of these drawings, Mr. Cotton and Mr. Roberts have spoken in high terms. Of their merits as mechanical drawings, the Institution has had ample opportunity of judging. The Council felt that to have attempted to distinguish betwixt the merits of these two communications would have been both difficult and invidious; they have therefore awarded a Telford Medal in silver, accompanied by books to the value of five guineas, both to Mr. Birch and Mr. Dempsey.

The Council have already spoken of the liberality with which Mr. Cotton had responded to the wishes of the Institution; his liberality stopped not however here; but he has promised to supply to the Institution that account and history of this machinery of his late distinguished friend which he alone has the power of doing.

On the other subjects then issued, the Council have not yet received any communications of great merit. They have, however, the pleasure of being able to announce that your Associate, Mr. Jones, has made considerable progress with an account of the Westminster Sewage; that your Associate, Mr. Johnson, has promised some drawings and models connected with the Breakwater; and your Member, Mr. Oldham, a communication on the means which he has adopted for warming and ventilation at the Bank of England. On the nature and properties of Steam considered in reference to its application as a Moving Power, and on the ratio betwixt the velocity, load, and power, of Locomotive Engines on Railways, no communication to which a premium could with propriety be adjudged has yet been received. The subjects on which no communication deserving a premium has been received, have consequently been issued with others for the present Session.

But though the Council received no communication in which the subject of steam was treated in the wide and comprehensive manner which was desired, they deemed worthy of premiums the following communications on parts of this great subject:—On the effective pressure of Steam in the Cornish Condensing Engines, by your Member, Thomas Wicksteed: On the expansive action of Steam in the cylinder of some of the Cornish Condensing Engines, by W. J. Henwood; and on the evaporation of water in the boilers of Steam Engines, by your Member, Josiah Parkes. To each of these, the Council have awarded a Silver Medal.

The communication by Mr. Wicksteed is of great value, as containing the only recorded experiment in which the water raised was actually weighed. It will be in the recollection of most present, that this is the second communication from Mr. Wicksteed on the same subject. The two are valuable additions to our knowledge on the subject. The water raised was weighed and measured. The weights raised in the stamping machinery were also accurately ascertained, and a comparison instituted between the duty of the single engine in raising water and of the double acting and crank engines in working stamps.

The communication by Mr. Henwood is remarkable for the extreme minuteness of detail with which the observations were conducted; the communication consists of two parts, the one on the quantity of steam employed and the mode of its distribution on the working stroke, the other on the duty performed with a given quantity of fuel. Under the former the Indicator is accurately described, and the evidence furnished by the diagrams explained. Under the latter is exhibited one of the most valuable specimens of detailed observations on record. It is a peculiar feature in the system pursued by Mr. Henwood, that he never interfered with the ordinary working of the engine; he observes with accuracy what is going on. Thus his paper is a record of observation in the highest sense of the term. It is of importance to practical men to keep in mind a distinction which has been often insisted on betwixt observation and experiment. In the former, the phenomena which are going on are noted, as they go on, the circumstances under which they occur being untouched—in the latter, the phenomena are produced for the purpose of the experiment. The former consequently requires great care in referring effects to their proper causes, the latter in guarding against the results being influenced by the circumstances necessary for the production of the phenomena. The two are distinct, each requires their respective talents, the former would lead a Newton to the law of Gravitation, and guide a Smeaton in the construction of an Edystone; the latter, a Watt and a Black to a knowledge of the properties of Steam; and the two combined a Davy, to the construction of a Safety Lamp.

In the communication of your Member, Mr. Parkes, we have an instance of both these methods combined; he observed what was going on under particular circumstances of evaporation, and then having altered the circumstances recorded the results of these experiments. The researches of this author led him to push slow combustion to its utmost limits. It would be foreign to the object of this report to trespass on the time of the meeting, further than to remark, that the contents of this paper may furnish many useful hints to the practical Engineer in the management of the fires of his Steam Boilers, and to the theorist some important facts towards a true theory of combustion.

The Council have also awarded a Silver Medal to the communications of your Associate, Lieut. Denison, on the strength of American Timber, and of your Member, Mr. Bramah, on the strength of Cast Iron. Each of these communications must be viewed as valuable additions to our knowledge. The series of experiments by Lieut. Denison was undertaken by that talented officer when stationed abroad, with a view of establishing some proportion betwixt the strength of different kinds of American Timber, and of affording a means of comparing it with European. It is a peculiar feature in these experiments, that the effect of time in increasing the deflection is noted. After the elastic limit is passed, the deflection increases with the time which the beam is loaded. The amount of this increase is recorded in most of these experiments. The Council cannot but regret, that Lieutenant Denison should have returned to this country before the very extensive series which he had contemplated, and for which he had made preparation, was complete; his intention of determining the change of strength and the amount of shrinkage betwixt green and dry was thus unfortunately frustrated, and they most earnestly concur with him in the expression of hopes, that officers and others employed in the colonies will be induced to turn their attention to this subject. They point out the above communication with especial pleasure, as an example to other Military Engineers, of the very valuable services which their opportunities will enable them to render to the science of the Civil Engineer.

The other communication by Mr. Bramah is also a valuable addition to our knowledge. Undertaken with a view of verifying the principles assumed in the widely circulated work of Tredgold, on Cast Iron, this series surpasses every other series in existence in its extent—the number of experiments being nearly 1500; and in the care taken to ensure accuracy, since two similar specimens of each beam were made the subject of experiment.

The principles, with the view of establishing which this series of experiments was undertaken, are, that the forces of compression and extension are equal within the elastic limit, and that consequently a triangular beam, provided it is not loaded beyond this limit, will have the same amount of deflection whether the base or apex be uppermost, and a flanged beam the same deflection whether the flange be at the top or the bottom.

This communication is accompanied by some valuable observations by your Associate, Mr. A. H. Renton, pointing out the agreement which subsists between the experiments and the results of the formulæ of Tredgold. The Council have peculiar pleasure in pointing out the preceding as communications of a kind on which they conceive the Telford Medals may be most worthily bestowed. The undertaking a series of observations and experiments with the view of establishing important physical principles, and from a desire after the truth, is an object worthy of the highest approbation of this Institution.

A Silver Medal has also been awarded to your Member, Mr. Green, for his communication on the Canal Lifts on the Grand Western Canal; to your Member, Mr. Harrison, for his communication on the Drops on the Stanhope and Tyne Railway; and to your Associate, Josiah Richards, for his most elaborate drawing of the Rhymney Iron Works.

The perpendicular lifts erected by Mr. Green on the Grand Western Canal involve some ingenious applications of simple principles, and present many considerations of interest to the Civil Engineer. The principles of their construction are simple, and the economy of construction and saving both in time and water gives them great advantages in certain cases over locks for the purposes of Canal navigation.

The Drops on the Stanhope and Tyne Railway for the purpose of shipping coals present another instance of simple mechanical adaptation. These have several points in common with the lifts just spoken of; the original drawing of these by Mr. Harrison is an exceedingly good example of what drawings of this nature ought to be.

Of the drawing of the Rhymney Iron Works, by Josiah Richards, it would be difficult to speak in too high terms; it is a most elaborate drawing, exhibiting all the details of the manufacture of iron. The Institution has not yet received the description which will be necessary to render the communication complete, but the Council have the gratification of stating, that your Associate, Mr. Rowles, the Chairman of the company, has promised that Mr. Richards shall be furnished with every facility towards completing a communication, which will undoubtedly be a most valuable acquisition to the records already existing in the Institution.

The Council have also awarded a Silver Medal to Francis Whishaw, for his history of Westminster Bridge. Of the great labour and research of Mr. Whishaw in collecting these documents, it would be difficult to speak in adequate terms. The history is extracted from voluminous records contained in the Bridge Office, and you are indebted also to the kindness of your Member, Mr. Swinburne, for the facilities with which he furnished the Author in the execution of this difficult task. The history of this Bridge, the only one of the old bridges now remaining, is interesting to the general reader, no less than to the Engineer. The difficulties which presented themselves gave rise to contrivances then for the first time brought into use, of which the introduction of caissons is not the least remarkable. The difficulties and progress of the work are well set forth in the reports of Labelye, of which the more interesting are embodied in this communication, and the account of the work furnishes a very complete history of the state of this department of practical engineering a century ago.

This communication, accompanied by an Atlas of eleven drawings, shewing the site and various details of the construction of the bridge, is one of those historical records which it is especially the object of this Institution to collect, and which, from the labour and research employed upon it, called for this mark of approbation of the Council.

The Institution received during last Session from your Member, Mr. Rendel, a very elaborate and beautiful set of drawings, accompanied by a suitable description, of the Torpoint Floating Bridge. This interesting communication is fresh in the recollection of most, and it would be difficult to speak in too high terms of the forethought, skill and design displayed in the construction of these bridges, and the perfect success which has attended their establishment. It does not often happen that the same individual has the genius to invent, and the good fortune to see his invention brought into general use. In this respect Mr. Rendel has been singularly fortunate, as these bridges have been already established in several difficult and dangerous passages. It would be foreign to the present occasion to dwell more at length on this invention; but the Council feel that in awarding a Silver Medal to Mr. Rendel, accompanied by a suitable record of the sense entertained of the benefit conferred by him on the inland communication of the country, this the highest acknowledgment in their power to make is most amply merited.

A Bronze Medal has been awarded to your Associate, Mr. Ballard, for the drawing of his Ice Boat, and description of his method of breaking ice by forcing it upwards; this simple method is applicable at about one-third the labour of the ordinary ice boat. A Bronze Medal has also been awarded to Thomas Macdougal Smith, for his drawing and account of Edwarde's or the Pont-y-tu-prydd Bridge, in South Wales. Mr. Smith being for a short time in the neighbourhood, availed himself of this opportunity to make accurate drawings of this curious and interesting structure. The Council would point out this as an example of the way in which every young man may, by availing himself of the opportunities afforded by his professional engagements, forward the objects which the Institution has in view; and they would earnestly impress on all young men the importance of availing themselves of such opportunities, and of recording their observations on every work with which they may be connected. This habit is of the greatest advantage to the individual, since only by such habitual self-improvement can any one hope to obtain eminence in the profession.

The Council have also awarded five guineas to Mr. Guy, for his method of making perfect spheres; this great desideratum in the mechanical art has been in a great measure supplied by the ingenuity of this individual, and a simple method furnished of readily producing spheres of metal or other hard substance with a great degree of accuracy.

The preceding are the communications of the last two Sessions to which the Council have awarded Premiums. The Council, in disposing of the premiums placed at their disposal by the munificence of your late President, have endeavoured to select from the great number of communications which have been brought before the Institution such of each class as especially deserved this mark of distinction. They trust that these premiums may act as a stimulus to many to forward to the Institution records of matters of interest to the profession, and that thus the object of the noble benefactor of the Institution will be fully realized.

The Council cannot dwell on the numerous communications received during the last session, of which an ample account will be found in the Minutes of Proceedings; they cannot, however, omit to remark on the great interest of the discussions, and on the value of the record of opinions and facts which is thus obtained. They would especially refer to the discussions on the duty of Steam Engines, and on the explosions of Steam Boilers, as having led to the collection of much valuable matter; the practice of recording the minutes of conversation is almost peculiar to your Institution, and is calculated in an especial manner to forward the interests of practical science.

Life of Telford.

The Council, in reviewing the events of the past year, cannot omit to express their gratification at the publication of the Life and Works of Telford. Every thing connected with his name is interesting to this Institution, and the Life and Works of so distinguished a man, written by himself, cannot fail to be received with the greatest satisfaction by all who knew him, or are able to appreciate his works. Through the kindness of your Honorary Member, Mr. Rickman, the Editor of the Life and Works, and acting executor of

Mr. Telford, the Institution has been put in possession of two copies of this valuable work.

Monument of Telford.

The Council have also the satisfaction of announcing, through the medium of this Report, that the Monument of Telford is nearly finished, and that a place has been found for it in Westminster Abbey. The site which the Telford Committee have selected, and hope to obtain, is one well adapted for the statue, and they trust that by the next Annual Meeting the monument will be placed among those, who, by the benefits conferred on their country, have justly deserved this tribute of respect.

Charles Tennant.

The Institution have to regret the loss, by death, of Mr. Charles Tennant of Glasgow, the eminent practical chemist. Mr. Tennant was born at Glenconna in Ayrshire, in 1767, and commenced his career as an improver in the chemical arts before the end of the last century. The great revolution in the practice of bleaching, which then occurred, was carried out by the discoveries made by him, first of the Solution of Chloride of Lime, and afterwards of the dry Chloride of Lime, or bleaching powder—an inestimable gift to the arts with which the name of Mr. Tennant will always be associated. The chemical works of St. Rollox near Glasgow, which now form so conspicuous a monument of his energy and success, were erected for the purpose of manufacturing this article, for which he held a patent.

The manufacture of Sulphuric Acid, and of Alkali from Salt, was also greatly improved at St. Rollox, and first conducted there on a scale commensurate with their national importance. The manufacturing interests of this country possess an advantage in the extraordinary cheapness of these and other chemical products, which they owe in a great degree to Mr. Tennant's scientific talents and activity as a manufacturer.

The arts are deeply indebted to Mr. Tennant for other benefits, particularly for his exertions in removing the duty on salt. This he ultimately succeeded in accomplishing, after a struggle of many years with the Kelp proprietors. Few legislative enactments have been so beneficial to the country, as is well attested by the rapid increase of alkali manufactories.

For some years past Mr. Tennant left the chief management of his manufacturing affairs to his Sons, and devoted a great portion of his energetic mind to the welfare of his fellow-citizens, among whom he was considered a leader in every philanthropic undertaking.

The success of railway undertakings occupied latterly much of his time and attention; the last great struggle in which he was engaged, was in favour of the Edinburgh and Glasgow line; the passing of the bill for which, he had the happiness to live to see.

He died at his house in Glasgow on the 1st of October, aged 71, and has left a name which will long continue to be extensively known and associated with practical science.

Presents.

The Presents during the preceding year have been numerous and valuable, and the Council have made several advantageous exchanges with other Societies publishing transactions. From the Society of Arts, from the Geographical Society, and from the Society of Literature, the Institution has received complete sets of Transactions. The Royal Society of Edinburgh, and the Philosophical Society of Manchester, have promised as complete a set as their stock will furnish.

The Council have also to acknowledge the continued obligations of the Institution to the Lord Lieutenant of Ireland, the Master General of the Ordnance, and Colonel Colby, for those Maps of the Irish and English Survey which have been published since the last Annual Meeting; they have also to acknowledge the liberality of your President, in presenting that beautiful painting of the Menai Bridge and adjacent scenery, which is placed in the Library. They have also to acknowledge the liberality of your Solicitor, Mr. Tooke, who has refused to accept any remuneration for the advice and information furnished to the Council, accompanying his refusal with the most obliging expressions of the deep interest he takes in the welfare of the Institution.

Cash Account.

The following abstract of the receipts and expenditure during the year ending the 31st of December, 1838, will shew the present state of the Funds of the Institution.

Dr.			
To Balance in hands of Treasurer	27	1	5
— Subscriptions and Fees	1040	0	6
— Dividends	71	8	10
— House Subscriptions	299	0	0
— Sale of Stock	183	0	0
	£1620	10	9

Cr.			
By House			
— Rent, Taxes and Repairs, No. 1, Cannon Row	140	6	0
— Repairs, &c., 25, Great George Street	250	0	0
— Lease of Ditto	24	12	0
— Salaries & Commission	353	12	1
— Postage and Parcels	20	13	8
— Stationery & Engraving	43	3	1
— Coals, Oil, &c.	47	2	8
— Tea and Coffee	34	6	5
— Printing	35	16	1
— Sundries	44	9	1
— Library	62	19	10
— Publications	36	15	0
— Furniture	52	9	0
— Telford Premiums	168	7	0
— Balance	305	18	10
	£1620	10	9

It will be observed with satisfaction that the balance in the hands of the Treasurer at the close of last year was £305 18s. 10d., whereas at the close of the preceding year the balance was only £27 1s. 5d. The statement of this balance does not represent the funds of the Institution in a sufficiently favourable point of view, as the amount of outstanding bills on the current expenditure at the commencement of the present year was considerably less than at the commencement of the last. The Institution also possesses £335. 3 per cent. Consols, available for general purposes, and a Lease of the House in Cannon Row, for which a good premium may reasonably be expected.

Conclusion.

In conclusion, the Council cannot but offer to the Meeting their sincere congratulations on the prospect which now lies before you. They congratulate the Meeting on the recent accession of many names distinguished in their respective branches: and trust that the details of the preceding report not only attest their own unremitting attention, but also will be found to record many zealous and talented efforts on the part of the General Body, to promote the objects of the Institution and the progress of professional knowledge. From every quarter has been received the most liberal aid and sympathy—the most cordial co-operation. That by which you have been enabled to meet in the present more spacious and convenient premises, will be readily appreciated.

The state of the funds is more prosperous than at any previous period; and in every point of view, the present condition of the Institution may form a subject of general congratulation.

The Council now resign into your hands the trust committed to them, with a sanguine confidence in the future importance and dignity, as well as prosperity, of the Institution, and of its forming a National Establishment for the advancement of professional knowledge, conspicuous even in an age of General Improvement.

ADDRESS OF THE PRESIDENT

TO THE

ANNUAL GENERAL MEETING,

JANUARY 15, 1839.

I thank you very sincerely for the manner in which you have expressed yourselves of my endeavours during the past year. It is truly gratifying to me if, through your partiality, I have been at all the instrument of forwarding this Institution, and the object of the excellent man whose picture is now behind me.

The task has been easy as well as gratifying; and for both I have to express my thanks to the Council, and to those who have attended the meetings. I have already gone through four Sessions, during each of which the importance of the Institution and the attendance at the Meetings have been on the increase; and during the whole of this time nothing has occurred to cause an unpleasant sensation, or to lessen that harmony which is so desirable. The discussions have generally been conducted with spirit, but no angry or personal expression has escaped the lips of any. This is the more gratifying, as these discussions have been on a great variety of subjects, some new, some very difficult and obscure, and generally the difficulty and obscurity of a subject, in other words the ignorance of it, is a measure of the violence with which it is debated.

At the last meeting a question was put by a gentleman, who, though not I believe an Engineer by profession, is most regular in his attendance, and whose remarks are always entitled to our best attention, as to the attendance of the Council. That this is an important feature in the Institution, it is impossible, and it would be a bad compliment to the Council, to deny; and now that the Institution is more before the public, and daily occupying a more important position, the succeeding Council will feel the increased importance of their position and of the duty that devolves upon them; and I am sure that the hint then delicately given, will not require to be repeated. And let me add, that, although on a few occasions I have lamented there was not a fuller Council, the attendance has on the whole been equal, if not superior, to that of any similar Institution. But we all occasionally require to be reminded of our duties; and while on the part of the Council I received the observations referred to as made with the best intention, so I trust those who are not of the Council will receive from me in the best part the observation, that they also have their part to perform, both in the enlarged attendance which these extended rooms will require to render them properly filled, and in the communication of matter to make the meetings interesting, and to increase the utility and importance of the Institution, so that the attendance may be not only from a sense of duty, but for the sake of the information and pleasure which are derived from them, as you must all feel to have been the case during the last Session.

There is really so much doing in this country alone, that without drawing largely upon genius, it would be sufficient to register but a proportion of the new works in progress to keep us fully employed, and surely the most timid Associate or Graduate need not be afraid of assisting in this. By the original bye-laws a Candidate for admission was required to present a drawing or paper; this has been waved, but still I consider the claim remains as almost a debt of honour, and the discharge of it would be found agreeable, if set about; agreeable not only in the execution, but in the anticipation of reward; and I would have gentlemen only reflect upon the subjects for which premiums have been adjudged, to see that the distinction requires no particular skill, but only resolution and moderate application; where there is the will, I am sure there is in this case an easy way. I am aware of the difficulty that frequently arises from indecision and in choosing a subject; a difficulty often felt and confessed by our most distinguished English Essayist. To remove this, the Council have given subjects for papers; and it has occurred to me that it might even be desirable to charge individuals with particular subjects—thus not only imposing more specially a duty upon the individual, but confining his attention to the particular subject (and even to limit the time)—both of which, I have found from long experience, the best preventives to wandering and procrastination.

Let us remember also, that as the importance of our profession is increasing, and is being felt, it behoves us to exert ourselves to maintain our relative station. Classes, with Professorships, for the education of the Civil Engineer, are established at our Colleges; and there is now upon the table a prospectus for the establishment, on a large scale, of a College for Civil Engineering.

We have every reason to be grateful for our success heretofore, but our motto must be "FORWARD," and we must keep up to it.

There is an ample harvest to reap from the new works which are going on throughout this country, from the Land's End to the northern extremity of Scotland, and in Ireland; and as the powers of human invention and discovery increase, the range for it becomes more ample—the higher we rise, the more enlarged is the sphere that bounds our prospect. There is reason to believe, from analogy, that we know as yet but a small portion of the powers and capabilities of matter, and which require but the application of mind to bring them to light. Much, I admit, has been done within the last century; but as our deepest pits are, when compared with the radius of the earth, but scratches on the surface, such, I believe, would our stock of knowledge, much as we think of it, appear to a mind that could comprehend all the properties and beauties of nature, even of that province with which the Civil Engineer has to deal; and this would appear the case to the last of a succession of Newtons, or Watts, or Huddarts, supposing each to add to the stock of his predecessor, even more strongly than it does to us. How much then ought we to admire that beautiful adaptation, which is fitted to man in every stage of his mental improvement! I sometimes doubt whether, when mechanical and other scientific improvements are made, we are disposed sufficiently to refer to nature, and then to rise to the Author of Nature, in admiration of the treasures which have been opened, and are still in store for mankind. Thus, in admiring the genius of a Newton, and others, we are not so disposed as we ought to be to carry our admiration back to the natural substances which have produced the Glass, without which the principal phenomena of Light would still be unknown; and to reflect, that these substances have existed from the beginning, although their combinations are of human discovery of no very ancient date. Again, when we admire the stupendous fixed or the active locomotive engine, or the fine machinery of Huddart, for drawings of which you have seen two premiums awarded, and reverence the minds which have brought these to their present state, let us not forget how small are these compared with the materials for steam and for manufacturing the steam-engine,—the water, the coal, and the iron; how insignificant these minds compared with the Mind which gave to them the properties they have,—to steam its elasticity and wondrous velocity,—and impressed upon matter those beautiful and uniform laws which govern it, and enabled a Huddart to calculate with certainty the strength of his materials, and what would be the result of his complex combination of wheels and pinions! What the poet said of the undevout astronomer, that "he is mad," may apply with equal truth to the undevout Mechanic or Engineer; and it would be well if those delightful feelings were cultivated, and invariably associated with the study and practice of the Engineer, so that his mind might in every pursuit dwell upon the wondrous adaptations of nature to the wants and pleasures of the community, and both in its lowest and most improved state be led to the contemplation of the Power which formed, and the Goodness which so admirably fitted the whole for the use of His Creatures.

I have been led without premeditation into this train of reflection. I gratefully acknowledge the attention you have paid to me on the present and on every occasion, and now leave the chair with a repetition of my thanks for all your kindnesses.

ORIGINAL COMMUNICATIONS.

Adie, I. On the Thermometric Steam Engine.

Bald, W. On the Construction of Roads on Deep Bogs and Moss.
Ballard, S. On the Construction of Lock Gates without Iron.
Bethell, J. On firing Blasts by Galvanism.
Birch, E. On Huddart's Rope Machinery.
Bourns, C. Table of Gradients.
Buck, G. W. On the Tubing of Locomotive Boilers.

Clegg, S. On the Dry Meter.
Cotton, W. On Captain Huddart's Improvements in Rope Machinery.

Dempsey, G. D. On Huddart's Rope Manufacture.
Dodds, J. On Improvements in Water Wheels.

Edwards, G. On the Steam Expansion Table.

Francis, C. L. On the Brick Beam at Nine Elms.

Green, J. On the Lifts on the Grand Western Canal.

Heald, G. On the Land Surveyor's Calculator.
Hemans, W. On the Brick Beam at Nine Elms.
Henwood, W. J. On the Expansive Action of Steam in the Cornish Engines.

King, N. On the Strata of Stone in the vicinity of Whitby.

Parkes, J. On the Evaporation of Water from Steam Boilers.
Pasley, Col. On the application of Bickford's Patent Fuzes to Blasting under Water.
Pellatt, A. On the relative heating powers of Coke and Coal in melting Glass.
Provis, W. A. Experiments on the flow of Water through Pipes of different lengths.

Rendel, J. M. On the Torpoint Floating Bridge.

Simms, F. W. On the Construction of Flat Roofs with Earthenware Pots.

Smith, T. M. Account of the Pont-y-tu-Prydd, over the Taâf, Glamorganshire.

Stuart, W. On the Limestone, Lime, Cement, and method of Blasting at Plymouth.

Timperley, J. On the bursting of the Boiler of the Union Steam Packet at Hull.

Tremenheere, Lieut. On some operations in Blasting in the Jumna and at Delhi.

West, W. On the Ventilation of Tunnels.

Whishaw, F. History and Construction of Westminster Bridge.

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Willis, Professor. On the Teeth of Wheels.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1839.

Jan. 8, 1839.

The PRESIDENT in the Chair.

Use of Peat Fuel.

At the close of the last session, a discussion took place on the use of peat in the manufacture of iron, and it was stated that the late Mr. Wilkinson, of Gateshead, smelted iron with peat fuel, and that the tools made from that iron were of a superior quality: that this iron was more malleable than Swedish iron.

Mr. Mushet was not aware that the smelting of iron with peat fuel had been recently performed. He could not conceive that the mere working of iron from bar into horse-shoes could produce any sensible effect; were the whole process conducted by peat fuel, the quality might be affected. He did not believe that peat could be used in the puddling furnace; it might, however, in the refining. It might be used in the smelting furnace, but with a diminished produce. For welding a hollow fire is necessary, and peat will not readily make a hollow fire; iron may be improved in point of hardness by the use of peat. He had analysed many kinds of peat, and never found one to contain less than 5 per cent. of earthy matter; many contain 20 per cent.; coal seldom contains more than 4 per cent. The common bog peat contains 25 per cent. of carbonate of iron.

Several present bore testimony to the improvement in the working of iron by the use of peat, and that better weldings were made by it in consequence of its freedom from sulphur. The absence of sulphur in peat was denied by Mr. Lowe, who had used it for making gas at Amiens, and the quantity of sulphuretted hydrogen produced in the purifiers was very great. The Newcastle coal varied much in its qualities; some is exceedingly bituminous, making abundance of gas, but abounding also in sulphur and pyrites. He never met with any coal which did not produce sulphuretted hydrogen—thus proving sulphur to be an element of coal. The Tanfield coal is peculiarly free from sulphur. Dr. Smith remarked on the great influence which the strata had on the quality and nature of the peat; that the Dartmoor peat differs from all other peat in that it burns with a red ash.

It was remarked that the smiths in Cornwall owe much to their long practice in the use of peat, just as the smiths of Pembrokeshire have learned to use anthracite. Both, however, would probably use pit coal, could it be easily procured.

Case Hardening

The conversion of iron into steel was discussed, and it was stated that iron could be converted into steel by immersion in pure carbon, as in the Macintosh process, at the rate of 1-30th of an inch per hour. Mr. Roberts stated the success of case hardening depended on the gentleness of the heat. Great care must be taken not to overheat, and case hardening might take place to the depth of 3-8ths of an inch in four or five hours. It was stated to be cyanogen united with iron which produces case hardening, but carbon which produces steel. An instance was mentioned by Mr. Carpmael in which animal charcoal was used for case hardening the interior, and vegetable charcoal for softening the exterior. Allusion was made to the fact, that the most perfect chill is obtained by the employment of moulds red hot.

Peat and Charcoal.

Mr. Farey alluded to the charcoal, or peat coke, which Mr. Oldham employs at the Bank of England; this is in thin cakes, and denser than the heaviest wood. Mr. Bramah remarked on the great value of compressed peat, could it be procured at a marketable price, on account of its superiority as a fuel for making large weldings.

The preceding minutes having been read, Mr. Parkes stated that the greater part of the charcoal used in Paris is from peat. The peat charcoal is preferred to the very best wood charcoal. There are two modes of making this charcoal: In a Swedish furnace, which is an oven made of lumps of peat: the pieces to be carbonised are placed in the interior, ignited, and smothered up in the usual manner. The other mode consists in getting peat as dense as coal, by allowing the small atoms to come within the natural force of cohesion. The peat for this purpose is dredged up from the bottom of streams, and laid up to dry, and formed into small bricks, which, on drying, contract very much. Compression will not do. In Holland they dig the turf and put it into running water. The water cannot be driven out by pressure. He had seen peat compressed with a force equal to that for pressing bowls for calenderers, but it was not near so dense as that formed by the natural means just alluded to.

Mr. Pellatt remarked, that the coking coal does not deprive it of the sulphur. Washing the coke will remove much that remains; but even then it cannot be used for welding glass—nothing but the purest beech wood will serve for this. Charcoal will not answer, as it requires a flame. By welding, he meant the operation of putting a handle on a vessel. The glass being of a proper temperature, a union is formed, provided no sulphur be present.

Mr. Lowe remarked, it had been practically found that beech charcoal is valuable because of the quantity of carbon it contains. There is more pure carbon in a given weight of beech wood than of any other kind. Oak is the next best.

Jan. 29, 1839.

BRYAN DONKIN, V. P., in the Chair.

"On framing Lock Gates without Iron Work." By S. Ballard, A. Inst. C. E.

Lock Gates.

The ledges, or horizontal pieces, are held to the back and mitre post by dovetail tenons and wedges; thus avoiding the use of iron T pieces and screw pins, which occasion the wood in immediate contact with them to decay, while the parts not pierced with iron are perfectly sound. This method was adopted in some gates on the Herefordshire and Gloucestershire canal, and after some years' experience, is found completely successful. Tar and white lead are put into the mortices, and the wedge driven down upon it, so that every crevice is filled, and the joints rendered water-tight; the planks, also, are fastened on with oak pins instead of nails.

Some discussion took place on the general opinion, that when dissimilar substances are in contact, as when a gate of one kind of wood is fastened with pins of another wood, some action tending to loosen the pins prematurely takes place betwixt them.

"On Tubing the Boilers of Locomotive Engines." By George Buck, M. Inst. C. E.

Tubing for Boilers.

In this communication, the author has attempted to determine the diameter of the tubes of the boiler of a locomotive engine, so that the effect in the generation of steam may be a maximum. The following are the conditions upon which the problem is solved: That the evaporating effect of the hot air, in passing through the tubes, is in proportion to the extent of surface in contact with the hot air, and as the time of contact conjointly. The following are the results of the investigation: The distance between the centres of two adjacent tubes should be equal to four times the interval between their internal surfaces—the diameter of each tube should be equal to three times the same interval—that the tubes should be as near each other as possible.

In illustration, Mr. Buck has drawn two sets of tubes of the locomotive boiler as generally employed, and one as they would be arranged according to the results of this investigation. On comparing the products of the aggregate periphery, and the aggregate area of the tubes, it appears that the boiler tubed according to the above theoretic proportion is from 23 to 26 per cent. superior to the others.

"On the State of the Suspension Bridge at Montrose, after the Hurricane of the 11th of Oct. 1838, with Remarks on the Construction of that and other Suspension Bridges, in reference to the Action of violent Gales." By C. W. Pasley, Col. R. Engineers; Hon. M. Inst. C. E.

Suspension Bridges.

By the hurricane of the 11th of Oct. 1838, one-third part of the roadway of the bridge at Montrose, with a very small exception, was carried away. The suspension rods on the west side were either broken or very much bent, but the chains, four in number, and extending in two parallel lines of two tiers each, appeared perfect. The distance between the piers is about 410 feet; and the chains had been strengthened by additional bars, or plates, since the bridge was erected. The statements of Mr. Provis, and the author's own observations, led him to the opinion that the motions which a bridge experiences are not lateral, but longitudinal. The Hammersmith suspension bridge does not appear to be subject to those longitudinal motions even in a most violent gale, and Col. Pasley considers this is amply accounted for by the longitudinal trussing which is there adopted. The idea that these longitudinal motions, and the injuries to the roadways of suspension bridges, are owing to the violent action of the wind from below, is confirmed by what Col. Pasley witnessed in Nov. 1836, at the Chatham dock-yard. One side of the roof of a shed for ship-building was raised up and down repeatedly, till at last a large portion of it, about 40 by 50 feet, was floated up like a sheet of paper, and carried to a distance of 50 yards. Such being the violence of the wind, we may readily conceive that the continual extension and compression to which the suspending rods must be subject by the rise and fall of the roadway, will in time break or bend them. This rise and fall of the roadway is prevented in the Hammersmith bridge by four lines of strong trussing along the whole length of the roadway, firmly connected to the bearers below; no similar trussing exists in the Menai, the Montrose, or any other suspension bridges which Col. Pasley has seen, or in the Brighton pier. The damage done to the latter, in Nov. 1836, is attributed, by Lieut.-Col. Reid, who witnessed it, to the action of the wind on the under surface of the roadway, and not to the lightning. The rise and fall of the platform of the Menai bridge is confidently stated to be three feet in ordinary gales, so that unless some similar trussing be employed, it may reasonably be expected that this bridge will be seriously injured in some hurricane. The peculiar construction of the suspension rods in several pieces, with joints, is a source of security to this bridge which the others do not possess. The author conceives that no suspension bridge of 400 feet betwixt the piers can be considered secure without two, at least, inflexible lines of longitudinal trussing from pier to pier.

Feb. 5, 1839.

The PRESIDENT in the Chair.

The following were ballotted for and elected:—Alfred Burges and John Taylor, as Members; Joseph Baxendale, J. M. Parsons, J. Bennett, as Associates; and Charles Wood, M.P., as an Honorary Member.

Corrosion of Substances

At the preceding meeting, Mr. Cottam had mentioned an instance of iron inclosed in lead for 90 years, being taken out with the fin and bloom unimpaired. Dr. Faraday inquired whether this was in London, as the quantity of sulphurous acid in our atmosphere from the coal we burn occasioned corrosions which do not occur in other countries. This was especially remarked by foreigners. Some years ago considerable discussion took place on the more rapid decay of the stone in the front of Somerset House, than of the same stone in other situations; it had not occurred to him to refer it to the acid in the atmosphere.

Mr. Sibley remarked, that Westmoreland slating, which is extremely durable in other places, will not last in London.

Mr. Cooper had often observed the large quantity of sal-ammoniac and muriate of ammonia always to be found in the atmosphere of London. This arose from the soot, the rain washing it out; as might be at once ascertained by collecting some water, during a shower of rain, on a clean glass—muriate of ammonia was always in excess.

Mr. Lowe inquired whether any one had observed in the spouts conveying water from the tops of houses a pellicle as of a volatile oil, or oxidable matter, on the first water from the tops of all houses, after a dry season. This peculiar pellicle is irradiscent, and disappears after a few hours.

Resin Fuel.

Mr. Williams laid before the Institution a series of specimens of turf, from the first state as taken from the bog, to the last when compressed, and after it was converted into a hard coke. He also described the new resin fuel, or artificial coal, and which was composed of resin and turf coke.

This resin fuel has been used in the Transatlantic steam vessel; and, besides its heating powers and the saving of weight, it enables the fireman to maintain the required pressure of steam with great regularity.

The mode of using it was described to be to throw it in front of the furnace, after the charge of fresh coal. The result was, the keeping up the steam until the coals burned up, and a better combustion of the coal took place. As the result of several trials, it was found that 2½ cwt. of this fuel was equal to 7 cwt. of Lancashire coal. It was not used alone, but associated with the coal. The vessels to New York took out from 40 to 60 tons each of it. Thus 2½ cwt. of the resin fuel and 20 cwt. of coal, was equivalent to 27 cwt. of coal. In practice, the steam vessels now carry and use a large quantity of resin, but which could only be used in connexion with small coal or cinders. This new fuel was, therefore, more economical than resin. The price was 35s. to 40s. pr t on.

Mr. Lowe remarked, that the statement of Mr. Williams respecting the peat fuel, led practically to inferences contrary to the results stated in Mr. Parkes's paper, and to Mr. Apsley Pellatt, and to his own experiments, viz. that 9 lbs of coke would do as much in any department of the arts as 12 lbs. of coal.

Results so diametrically opposite, and from persons working on the large scale, and of known accuracy, were not to be disputed. It seemed that we had either yet to learn some unknown laws of combustion, or that the experimenter had not been alive to the differences resulting when combustion was conducted under the widely different circumstances which each experimenter might have in view. Mr. Parkes's test was the evaporation of a known weight of water by a known weight of fuel, coke or coal, employed. Mr. Pellatt's test was the circumstances most beneficial to the temperature of a glass-house furnace. Now these results, wonderful to relate, were strictly in accordance with the results of the experiments of Marcus Bull of Philadelphia, whose test was the raising the temperature of a chest of known cubical contents (512 feet), by 10 degrees of Fahrenheit. All these experimenters find that, so far from coal and coke having the same value, it requires 4 lbs. of the former to produce the same effect as 3 lbs. of the latter. Now it does appear that the results of Mr. Williams are conflicting with these. He finds that equal work is produced in the marine engine by substituting 1 ton of a mixture of peat and resin for 4 tons of coal, which coal, in its composition, weight for weight, must contain a far less quantity of hydrogen and oxygen than is known to exist in the generality of peats. It appears that 1 ton of peat and of a hydrocarbon, far more inflammable than coal, supersedes all the carbon, hydrogen, oxygen, and a little nitrogen, combined in four tons of coal. I would suggest as a theory for investigation, whether it may not be found that the coal or other fuel, which contains chemically combined the least oxygen, will not in its combustion give off the most available heat, owing to the oxygen combining with the hydrogen producing less water, which, as aqueous vapour, will carry up the chimney a large portion of the heat, but in a latent state.

Mr. Cooper remarked, that Marcus Bull's experiments were hardly applicable to the present inquiry, as he had constructed a box by which to ascertain how much air was heated by a given quantity of fuel, looking more to the domestic economy of the fuel than to its uses in the arts.

Dr. Faraday was of opinion, that a close comparison ought not to be instituted betwixt the application of heat to glass pots and to a boiler. In the former case an immense quantity of heated air passed away as in the smelting furnace for iron, where a greater weight of air passed through the furnace than all the other materials, as coal, limestone, and iron-stone; in the latter case there is an immense demand for latent heat. We know that a very small quantity of fuel is sufficient to heat and keep hot a large mass of matter where there is no rapid absorption of latent heat.

The experiments just referred to shew little as to the absolute quantity of heat in different fuels, as there was so great a difference in the quantity worked out in the two cases. To imagine that the coke of a chaldron of coals should produce as much heat as the chaldron of coals could not be the case, or the heat of the coke oven would go for nothing. But there is so great a difference in using coke and coal for heating glass pots and under a boiler, that the two cases cannot be compared. He should conceive that very great advantages might result from having a resin fuel in the front of the fire; the resin would, perhaps, not be advantageous by itself, but more advantageous with an inferior than with a superior coal.

Heat of Coke Ovens.

Several instances were mentioned in which it had been attempted to render the heat of coke ovens available for other purposes; the results were very contradictory. Many patents had been taken out for this purpose, but they failed. In one case, a coke oven heated the boiler of a steam engine, but the steam generated was barely sufficient to move the engine when doing no work. It was found, also, in some experiments, that a proper coal for coking being used, there was no available heat for the generation of steam,—an improper coal being used, there was steam, but little coke.

Analysis of Coal.

Mr. Lowe remarked, that the analysis of coal was very imperfect. One author tells us that cannel coal contains no oxygen; but the gas maker knows that this coal, though previously perfectly dried by being brought to a boiling heat, yields three times as much water, called ammoniacal liquor, as any other coal. This results from the combination of the elementary oxygen and hydrogen producing water, which as vapour is extremely greedy of heat. It was an important inquiry, whether the quantity of elementary oxygen in coal may not occasion the difference between it and coke.

Mr. Williams stated that peat employed in connexion with coal makes a most improved coke. If one-fourth of Lancashire peat be added to three-fourths of coal, a coke which the iron-masters pronounce to be the best for the manufacture of iron is produced, whereas coke from the coal simply cannot be used for this purpose.

Extracts from Smeaton's MS. Papers, communicated by John Farey, M. Inst. C. E.

Smelting Iron with Peat.

Mr. Smeaton, in a letter dated 25 Nov. 1778, remarks, that he had seen at Furness Fells in Lancashire a Blast Furnace for smelting iron with peat. This peat iron, made by Mr. Wilkinson, possessed extremely small grain, and the metallic atoms being very closely combined; and was found to answer well when mixed with other iron for making slit mill rollers.

Use of Peat.

Mr. Farey also communicated some extracts from the papers of Mr. Mushet respecting the manufacture of iron with peat; the quality of the fuel, and the nature of the iron produced therefrom.

Feb. 12, 1839.

The **PRESIDENT** in the Chair.

The following were ballotted for and elected:—Robert Hawthorn, Nicholas Harvey, William West, as Members; J. R. M'Clean, as a Graduate; E. W. Brayley, as an Associate; and General Sir John F. Burgoyne, R.E., as an Honorary Member.

Iron and Cement.

Mr. Simpson presented some pieces of iron hooping which had been imbedded for 26 years in cement, and which were blue as when first put in; the iron hooping had been placed round stone pipes at their junction, and covered with cement. From these specimens it is evident that a coating of cement is a perfect preventive of corrosion.

"On the Properties and Composition of the Peat and Resin Fuel." By C. Wye Williams, A. Inst. C. E.

Peat and Resin Fuel

The nature of the fuel being of great importance in the manufacture of iron and arts generally, it is interesting to inquire into the value of peat for these purposes. Peat may also be used for railroad engines, and with peculiar advantage, being free from many of the impurities of gas cokes: it may also be used in combination with resin, or other bituminous substances, as a fuel for long voyages. The bogs of Ireland were, nearly 30 years ago, designated by a Mr. Griffiths as mines above ground; who remarked, also, that the iron founders in Dublin might probably, ere long, be supplied with turf-charcoal, which is superior to every other for their purpose. The attention of the author was directed to the use of peat for the steamers on the Shannon, where coal is necessarily dear, and peat was at first used only for economy; the impediments to its use, from its bulk and dampness, being great. The property of holding and absorbing moisture is also a great impediment to its use, particularly in wet seasons, the only remedy for which is great care during the process of drying and in its subsequent preparation, any care being amply repaid by the diminished consumption. The evils of its bulk and low specific gravity may be obviated by compressing it when dry; when compressed perfectly dry, and kept free from moisture, it will preserve its bulk. From some observations of Tredgold, respecting the earthy impurities and odour of peat when burnt, it is obvious that he experimented on peats from the lower strata; but the author, in opposition to several eminent philosophers, maintains that turf coke may be made more effective than wood charcoal. The author, in his first experiments, came to the same conclusions for using the lower though impurer strata, simply because they were the denser, and rejecting the lighter kinds. The lower strata sometimes contains peat of a tolerable purity, but generally the upper and lighter portions are superior in the purity of the carbon, the intensity and quality of its heat, to those portions which have acquired density by time and natural pressure. When the density is acquired by artificial pressure, we have a substance superior to any other for all purposes of metallurgy.

The difficulty in the conversion of turf into coke has hitherto lain in depriving it of its volatile substances, so as to make a pure carbon, and in avoiding waste by partial combustion. This is effected by an union of the distillatory with the stifling process; the volatile substances are expelled in the oven, and when sufficiently charred the stifling process is adopted. Turf for the forge must have a greater density than that acquired by this process. This is effected by pulverising or bruising it, so as to destroy the fibrous character, and bring the component parts into closer and more permanent contact. By the union of these processes, any density may be given to the fuel which will combine the purity of vegetable charcoal with the density of mineral coke. The specific gravities of the turf hard pressed (water being 1000) is 1160—of the coke from the hard pressed 1040. Thus, the hard pressed turf is denser than the densest wood, and the turf coke double the density of charcoal and equal to coal coke.

The test adopted by the author, after Berthier, of the calorific power, or relative power of absorbing oxygen, is the quantity of metallic lead reduced from its state of oxide by given weights of the several fuels. Pure carbon gives 340 grains, wood charcoal 307, turf coke 277, best coal coke 277.

Thus we have a measure of the relative quantities of heat; but intensity of heat is often of more consequence than quantity, and intensity depends on the density of the fuel. Berthier remarks, that the superiority of coke to wood charcoal is owing to its density. In the above comparison, no account is taken of the impurities of the fuels; consequently, turf coke, being free of sulphur, has great advantages. The author finds that iron worked with turf coke is sooner brought to a welding heat, works softer, and comparatively free from scales.

The author then describes the resin fuel as an artificial coal produced by imitating the process of nature, in the best combinations peculiar to coal. Natural pit coal consists of bituminous, carbonaceous, and various foreign ingredients, of which sulphur is in abundance, and very injurious. The resin fuel consists of resin, the purest available bitumen, and turf coke, the purest vegetable carbon. Thus, the greatest heating power exists in the smallest bulk, and the excess of bitumen and deficiency of carbon, as in cannel coal, or excess of carbon and deficiency of bitumen, as in anthracite, may be avoided. Resin, notwithstanding its price, is used in steam navigation, but very disadvantageously, in combination with cinders, as it melts and passes off in a state of vapour, not entering readily into combustion with the oxygen of the atmosphere. But in the resin fuel, in consequence of the extraordinary attraction which subsists between carbon and oxygen, the resin has its full combustible and calorific effect. In the furnaces of boilers, a solid cinder is requisite, which may be produced by adding some of the inferior bitumen, as pitch and tar. The fuel is manufactured by adding turf coke, in a state of powder, to the bitumen in a melting state, and in such quantities as to saturate each other. The average price of the fuel is 40s. per ton. Its use was fully tested in the voyages of the Royal William, in which 20 cwt. of coal, with 2 cwt. of the fuel, did the work of 26 cwt. of coal. The suddenness of the action and the great increase of heat for a small increase in its consumption, render it of great value in cases of emergency. The author concludes by expressing his conviction, after ten years' experience, that the turf bogs of Ireland may be rendered available for many important uses in the arts.

Coke Fuel.

Mr. Lowe called the attention of the meeting to the valuable mass of facts which had recently been recorded. It was on these that the chemist must build his theory of combustion, and not strain his theory to the facts. We cannot doubt the facts of Apsley Pellatt and Josiah Parkes; men of undoubted acuteness and close observation, and not to be deceived. Marcus Bull again, under totally dissimilar circumstances, viz. the raising by 10° the temperature of a chamber, exquisitely insulated, and observing how long it can be maintained at this temperature by a given weight of different fuels; and accurately noting the loss sustained by the wood in the process of coking, came to similar results. With respect to shell bark hiccory, whose specific gravity is the same as that of water, and loses three-fourths of its weight by coking, Marcus Bull finds that equal heat is produced by 6⅔ lbs. of hiccory charcoal, and by 15 lbs. of dry wood. So that we may say a given weight of the dry wood produces just double the effect it would if made into charcoal.

There is clearly something in coal and wood whose action is not beneficial, as the residual coke does, according to these three men, produce the same effect as the original weight of fuel. The *resumè* of these experiments shews, that to deprive bituminous coal of certain portions of oxygen, carbon, and hydrogen, is not to depreciate its heating powers; according to Mr. Williams' experiments we find, that to add a bituminous substance to a pure coke or carbon, is greatly to increase its heating power. It is fearful to think how often we are self-deceived; men do so lean to their preconceived notions and to their wishes. He could almost always get a yea or a nay indifferently from his workmen. The person who would not be deceived, and rightly study the laws of combustion, must himself turn stoker.

Coke Ovens.

To say that no heating powers are given off by the process of coking, would be just as absurd as to give credence to the statements that every thing can be done by coke ovens. This is proved by the statements of Mr. Cubitt, in the first volume of the Transactions, who applied, at Ipswich, the waste heat of coke ovens to heating gas retorts, and the same is still done at Reading. Whether the coke it produces is equally good with that made in the usual routine, remains to be proved. But to say that the 15 cwt. of coke, produced from a ton of coal, is equal in heating powers to the original ton, is to say that there were no heating powers from the 9 or 10,000 cubic feet of gas produced, or the 10 gallons of tar. The contrary is self-evident, and the whole mystery is cleared up by supposing that in the ordinary routine of furnaces most of the bituminous and gaseous products pass up the chimney, asking for heat rather than giving any off.

Mr. Horne particularly called attention to the fact mentioned by Mr. Williams of the fibre being broken down. Most experiments on compression had failed from this having been neglected.

Mr. John Taylor had for seven years worked coke ovens for the purpose of distilling wood. Several tons of coal were coked every week, and three large retorts, 6 feet by 8, were worked. The heat of one coke oven was effective for four of these retorts, and the coke sold for the cost of the coal. Here there was clearly an available heat. There is great difference in the mode in which fuel is employed; coke is peculiarly valuable in a locomotive, because of the draught; the bituminous coal of North Wales is bad for steam engines, as compared with the coal of South Wales. Of this he knew a striking instance. Soon after Messrs. Grose had erected, in Cornwall, their famous 80 million engine, one in every respect similar was erected in North Wales. A duty of 70 or 80 millions was expected. It never rose above 45°. They tried some Swansea coal—the duty immediately reached 70 millions. The bituminous effect of the North Wales coal is lost—it distils off; and this is shewn by the fact, that when fresh coal is thrown into the furnaces in North Wales a cloud of smoke issues from the chimney, but in Cornwall no smoke is visible.

They once had occasion to try wood, and the hot blast which succeeds so well with coke will not do with wood, and in all the metallurge process the wood must be coked. Turf charcoal has, to his knowledge, been in use at Dartmoor for forty years. For welding, and all fine works, it is the best. Peat has been most extensively used in the North for smelting lead ore; now a small quantity of coal is mixed with it. He had used peat in a reverberatory furnace for calcining lead ore, and for this purpose dry peat, with a small mixture of coal, is very valuable. Could a cheap and simple process be employed for expressing, the water peat would be an extremely valuable fuel.

Mr. Cottam stated, that he had two years ago built a coke oven for coking two chaldrons at a time. A boiler was placed above it from which the steam engine was worked. The coke from under the boiler did not make as much iron as other coke. When the boiler was placed by the side more fuel was required, but a better coke was produced. Good coke requires a reflected heat, and that produced in an oven of good fire-brick will produce a better charge than the coke from any retort.

February 19, 1839.

The PRESIDENT in the Chair.

The following were elected:—J. A. Galloway, as a Member; E. Birch, as a Graduate; G. Moore, C. Robinson, S. Reed, as Associates; and Capt. Sir E. Parry, as an Honorary Member.

Coke Fuel.

Mr. Pellatt remarked, that regard was to be had to the manner in which the coke was consumed. He had seen in Lancashire a glass manufactory worked by four coke ovens, the pots being placed above them. The ovens were not of the ordinary nature in London, but holding only two tons, with flues by the side to take in air from the atmosphere. The coal was bad and the coke not taken an accurate account of. But it was stated that a ton of coal only produced 10 cwt of coke, whereas with us it produces 14 cwt.—thus there was a loss of 4 cwt. In the ordinary process the ovens are drawn once every twenty-four hours; here they are drawn more frequently, and small coal is supplied till the time of their being drawn. To this some of the loss might be attributed.

Mr. Lowe remarked the difficulty of ascertaining the specific gravity of coke; you could not be certain of its being saturated. The best means with which he was acquainted was to place it under the receiver of an air pump, so as to be sure of all the air being withdrawn, and every vesicle filled with water. Perhaps boiling is the next best. At first gas coke floats. Thus, pumice stone which floats consists of exceedingly heavy particles when comminuted.

"On Railways in America." Communicated in a letter to the President, by S. W. Roberts.

Railways in America

The writer describes the various methods which had been adopted of laying down Railways in America during the last twelve years. First, timber rails with light flat iron bars were tried; these were found cheap, but not durable. Next, stone rails or sills similarly plated. Next, heavy iron rails laid on blocks of stone; the violent vicissitudes of the seasons soon deranged the foundation of these, and caused the track to spread. The heavy iron rails were next laid on a foundation of timber. The Alleghany Portage Railroad was laid four years ago by the writer with hewn white oak timber, 10 inches square, imbedded in the ground; upon these cross sills of locust timber, 6 by 8 inches, and 7½ feet long, notched and trenailed. On the top of these cross sills, and directly over the longitudinal timbers, the cast iron chairs which supported the rails were bolted. The track was thus effectually prevented from spreading. The rails are from 45 to 60 lbs. per yard, from 3 to 3¾ inches in height, and from 3¼ to 4¼ inches on the base. On roads with difficult curves "bogie" engines are used. Each locomotive has six wheels. The hinder part is supported by a pair of driving wheels, 4 to 5 feet in diameter, and the front part rests upon a bolster on the bogie, which has four wheels of about 33 inches diameter. Each passenger car is 36 feet long and holds fifty persons, and warmed by a stove. The long cars are adopted as less likely to upset than those on six wheels. The average speed, including stoppages, is 15 miles per hour.

"Manchester and Leeds Railway Section." By Francis Whishaw, M. Inst. C. E.

Railway Sections.

This section, prepared under the direction of Mr. Whishaw, is designed to afford a novel and useful method of embodying a great mass of the details required by an Engineer when giving evidence before a Parliamentary Committee. This section was constructed before the last standing orders, and the author had here anticipated them in putting upon this section much of the detail now required. By sections thus prepared the engineer can always answer any questions which may be put to him.

"Account of Boring for Water through Granite." By Frederick Holland. Communicated by Apsley Pellatt, A. Inst. C. E.

Boring in Granite.

A hole, 6 feet wide and 7 feet deep, was first dug, and a wooden cylinder lined with bricks inserted. Two pieces of cast iron pipe, 6 feet in length and 8 inches in diameter, turned smooth at both ends, and united by a wrought iron hoop ring, so that when the whole number of pipes were driven, a continuous pipe, perfectly cylindrical, both on the inside and on the out, was formed. Nine lengths of pipe were connected and driven, and then the boring commenced, and continued through a hard rich species of rock or granite, having all the component parts but not the compactness of granite. The boring was continued to a depth of 175 feet. The supply has been regular at the rate of from 48 to 50 gallons per minute, a temperature of 48° F., the external air being 52½° F.

Thames Tunnel.

Mr. Brunel stated, that the advance of the Thames Tunnel was now at the rate of 3 feet per week; they were now 64 feet from low-water mark. He presented some specimens of sand, which, when mixed with a certain quantity of water, was exceedingly troublesome. They frequently push the poling boards before them: last night not less than 60 square feet was pushed before them. They fight their way on with difficulty, but continuously.

February 26, 1839.

The **PRESIDENT** in the Chair.

The following were elected:—G. Grove, J. B. Redman, as Graduates; S. M. Peto, T. Grissell, Rev. S. King, as Associates.

"On the Economy of working expansively in Crank Engines." By John Watt.

Working expansively.

A letter from Mr. Watt was read on the economy produced by working steam in large steam engines expansively, in which the author details the result of some experiments on a high pressure engine, employed for blowing furnaces. The steam cylinder of the engine in question was 38 inches in diameter, the blowing cylinder 122 inches, length of stroke 9 feet, pressure on the piston as shewn by indicator diagrams 41 lbs., and in the boiler 45 lbs. per square inch, the number of strokes about 12 per minute, and the pillar of blast 2½. A large fly-wheel was attached, and on fitting the steam engine with an expansive apparatus and cutting off at half-stroke the performance was greater than at any previous time, and with a saving of 25 per cent. of fuel. The author refers this to the fact that all the moving parts, with the exception of the fly-wheel. are brought to a state of rest at the conclusion of each stroke, and that if the steam be allowed to enter throughout the whole length of stroke, the piston will have to draw from the fly-wheel momentum sufficient to overcome the momentum, and to alter the direction of the reciprocating parts, but the steam being cut off so that the momentum is destroyed by the time the piston terminates its stroke, the return stroke will be commenced without checking the unnecessary impetus which exists when the steam is admitted to the end of the stroke. Thus it is observed, that engines working expansively pass the centres more easily than when working full pressure throughout the stroke. The momentum which has to be destroyed is created at the expenditure of more than half a cylinder full of steam; and the checking this motion is also accompanied by a still further waste of steam. Mr. Watt had altered an engine driving rolls for rolling iron, and the result of cutting off at half-stroke was here also attended with a saving of 25 per cent. of fuel.

In the preceding paper part of the good results of the Cornish engines was attributed to the momentum of the column of water. Mr. Enys explained that the quantity of water is small as compared with the mass of the pump rods: in the Cornish engines this mass of matter is put in motion by a violent jerk; the proportion of weight of the pump rods to the weight of water is about 150 tons to 37 tons. He believes that one cause of the economy of working expansively is the boiler room not being sufficient when the engine works at full. There is an immense superiority in the working of an engine which has abundance of boiler power, over the working of one in which this is deficient. The high pressure boiler never evaporates as much water as the low pressure boiler, the circumstances being the same. There were many curious facts connected with the evaporation and the duty. It sometimes happened that the duty was less for a greater quantity of water supplied to the boiler; this must be referred to leakage. Another difficulty which he had experienced was in making the theoretical diagrams come up to the indicator diagrams; this might be owing to the piston not following the pressure with sufficient quickness.

March 5, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected :—Thomas Chalmers and Andrew Burn, as Graduates ; and John William Lubbock, as an Honorary Member.

" On the comparison between the power of Locomotive Engines and the effect produced by that power at different Velocities." By Professor Barlow, Hon. M. Inst. C. E.

Power and Resistance in Locomotives.

In this communication the author attempts to lay down an appropriate method for computing the power of locomotive engines ; and though this method will not serve to exhibit the absolute power of the engines, it may serve to exhibit the comparative power under different conditions. We know the number of cubic feet of water evaporated in any given time ; the space passed over in that time ; the diameter of the driving wheels ; the length of stroke ; and the capacity of the cylinder ; we hence know how many cubic feet of steam have been employed, and consequently the mean number of cubic feet of steam produced from one cubic foot of water. Again, by experiments that have been made by different writers upon the elastic force of steam, we know the pressure per inch on the piston, and then making due allowance for the resistance of the atmosphere on the piston, the friction of the engine gear, &c., there remains the force that ought to be effective on the piston. This being reduced to the circumference of the wheel, should be equal to the resistance opposed by the load, which on a level plane consists of axle friction, road resistance, and the resistance of the atmosphere to the engine and carriages. But this is assuming that the engine has a perfect action, without any waste, which, however much to be desired, can never be the case in practice. Thus comparing what ought to be done in overcoming resistance with what is done, we shall learn the amount of power wastefully expended.

The author then selects some experiments from those made on the North Star and Harvey Coombe Engines, as reported by Mr. Wood to the Directors of the Great Western Railway, and illustrates by these the proposed method, and exhibits the results in tables.

From one of these experiments it appears, that the steam power expended per ton of the gross load amounts to 32 lbs., whereas on a tolerably level line it is generally assumed that the retardation of such a load does not amount to more than 9 lbs. per ton ; so that there appears to have been a power expended more than three times as great as the mechanical resistance to which it was opposed, according to views hitherto taken on the subject.*

The author then proceeds to consider the resistance to Railway trains at different speeds, and these resistances he refers to, 1st. That of the atmosphere. 2nd. The friction of the axles. 3rd. The road resistance. He discusses several experiments made by Mr. Wood, and remarks on the great discrepances which they present—the atmospheric resistance in one case amounting to 353 lbs., and in another to 99·7 lbs. at the same velocity, viz. 32½ miles per hour; the friction in the former case being 5 or 6 lbs., and in the latter 20 lbs. per ton. The results of the best experiments on the atmospheric resistance and on friction shew that the former must be considered to vary nearly as the square of the velocity, and the latter to be constant, or independent of the velocity; but this law of the constancy of friction, owing to the peculiar circumstances of the case, cannot hold with respect to the axles of railway trains.

Very much must be attributed to the increase of the road resistance as due to the deflection of the rails at high velocities, and to the state of oscillation to which all the parts of the carriages are subject, and the imperfection of the joints. The author proceeds to make some observations on the actual state of our knowledge with respect to the atmospheric resistance, and the effect of inclined planes on the working of a line of railway. The speed in descending planes is limited by considerations of safety, and in planes of $\frac{1}{96}$ $\frac{1}{100}$ and $\frac{1}{220}$ it is not safe to descend with heavy loads at a greater mean rate than is attainable with the same load on a level; that on planes between $\frac{1}{750}$ and a level the whole attainable speed is admissible.

The method of inferring the power of an engine from the quantity of water evaporated was objected to on the grounds that so much water is lost by priming.

With respect to the resistance due to the imperfection of the joints, it was remarked that Engineers are generally so much restricted as to the expense of making the joints of rails, they cannot adopt that which is the best; and it is a question well worthy of attention, whether the best kind of joint is not the most economical, as the wear and tear would be diminished, and the comfort of the passengers increased, by attention to this point.

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* One experiment shews an expenditure of power amounting to 72 lbs. per ton, which is from eight to nine times greater than the usually admitted resistance. It is evident, then, that the resistance has hitherto been taken too small with high velocities. To what are such remarkable differences to be attributed—to different proportions in the parts and weights of the engines, or to the velocities?

The experience of the Dublin and Kingstown Railway shewed that great advantages would result from a better kind of joint being used. This railway, though so short, and only having been finished about three years, has had perhaps more frequent traversings than a longer railway would in fifteen years; the trains started every half hour, and frequently the departures were increased to every quarter of an hour: the opportunities of observing the effect of the carriages upon the rails were therefore excellent.

"Description of a Machine called a Floating Clough." By George Ellis, Grad. Inst. C. E.

Floating Clough.

The machine here described is used for scouring a channel which leads from the Winestead Drainage and Haven of Pattrington, into the river Humber. It is constructed in the following manner:—The frame is made of timbers 6 inches by 4, 12 feet long, 9 wide, and 6 deep. This frame is covered with planking 2 inches thick, and through the middle of it a culvert is formed with planks, 2 feet 6 inches in width, with a small lifting door at one end. Connected with the bottom and projecting in front are two long beams called feelers, which keep the machine in its course, and in the front are frames of wood shod with rough iron like the teeth of a saw, and these are connected with racks which can be raised by a lever.

At each side of the machine there is a wing which is made to fit the slope of the banks, to dress the mud from the sides, and to keep up the water behind the machine.

At high tide the machine is moored in the middle of the channel, the wings are extended and kept so by ropes, and when the tide is at half ebb the plugs are taken out, and the water rises about 2 feet in the machine, which causes it to sink; the plugs are replaced, and thus it remains till full ebb, when the iron-shod frames are let down in front, and the tide forces the whole machine, which is like a great dam, gently down the stream, scraping with it all the mud down to the river, where it is emptied, and floated back with the return tide. The whole distance, about three miles, is performed in two hours. A machine of the same kind is used with great advantage at Great Grimsby.

March 12, 1839.

The **PRESIDENT** in the Chair.

The following were balloted for and elected:—Philip B. Scott, as a Graduate; Thomas Cubitt, John S. Enys, and Robert Mallett, as Associates.

"Description of the machinery and the several processes for converting refined metal into malleable finished iron at the Rhymney Works." By Josiah Richards, Assoc. Inst. C. E.

Iron Works.

In this paper the author explains and describes the elaborate drawing of Puddling Furnaces, Forge and Rolling Mills, at the Rhymney Iron Works, presented by him last session to the Institution, and the various processes necessary for converting refined metal into finished malleable iron. Each puddling furnace usually receives as a charge 4½ cwt. of refined metal, which is worked by the puddlers into six puddle balls in about an hour and a half. There are three sets of puddlers to each furnace, who relieve each other every five charges. The puddled balls are drawn on wheeled trucks either to the hammer, weighing about 4½ tons, with a fall of 20 inches, where each receives about twenty-five blows, or to the squeezer; but this latter method does not get rid of the impurities so effectually as the former. The ball is then passed through a continually decreasing series of grooves in rollers, whereby it becomes puddled, or No. 1. Bar. The bar is then cut into short lengths, allowed to cool, and made into piles of a particular weight and size, according to the description of the iron that is to be rolled; these being placed in a furnace are brought to a welding heat, and then passed through rolls and reduced to the requisite size, when they become No. 2. Bar. The same operation of cutting, filing, heating, and rolling, being again gone through, the iron becomes No. 3. Bar, or Railway Iron. No. 3. iron may be made from a pile, of which the top and bottom are of No. 2. iron, and the middle of No. 1. It is then brought to a welding heat, and hammered so as to be soundly welded; being again heated, it is rolled into No. 3. or Railway Iron.

The rail is received from the rolls on a carriage, and carried to a circular saw, where one end is cut off; the rail is then allowed to cool, and afterwards the other end is heated, and the rail cut to the required length.

March 19, 1839.

The PRESIDENT in the Chair.

On Mr. Smeaton's "Estimate of Animal Power, extracted from his MS. Papers," by John Farey, M. Inst. C. E.

Animal. Power.

The amount of mechanical power has been frequently over-stated, in consequence of the conclusions being drawn from efforts continued for too short a time. Desaguliers estimated the power of a man as equal to raising 5507 lbs one foot high per minute; this was found by Smeaton to be too high; several experiments are recorded, in which different values are assigned to the power of a man, and he ultimately fixed it at about $\frac{2}{3}$rds of the above, or 3672 lbs. Several experiments are recorded of the estimate of the power of a horse, and of the quantity of water raised by various machines.

The communication is accompanied by a letter in Mr. Smeaton's hand-writing, dated 21st Feb. 1789.

"Account of the firing of gunpowder under water, by the voltaic battery at Chatham, March 16, 1839, under the direction of Col. Pasley." By F. Bramah, Jun., A. Inst. C. E., and C. Manby, A. Inst. C. E.

Firing under water, by Galvanism.

Exp. 1.—A tin canister containing 45 lbs. of powder was sunk in deep water, and the coil containing the conducting wires, $\frac{1}{5}$th of an inch in diameter, by which the powder was to be fired, was veered out to its whole length of 500 feet from the boat in which the voltaic battery was placed. The connexion being made the explosion was instantaneous, and the concussion was felt very sensibly on the shore.

Exp. 2.—Three canisters, each containing a charge of 5 lbs., were sunk at a distance of 50 or 60 feet from each other, and a pair of connecting wires, 100 feet long, were attached to each; the ends of these wires were soldered together by threes, and on the connexion being made only one of the canisters was fired. The wires in this experiment were of common copper bell wire, about $\frac{1}{16}$th of an inch in diameter. The voltaic battery used was one of Professor Daniell's improved construction. The preparation of the conducting wires, and the manner of discharging the battery, appeared the same as described in Mr. Bethell's communication of last Session.*

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* See *Minutes*, April 24, 1838.

March 26, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected:—G. A. Oldham, as a Graduate; Sir John Scott Lillie, Captain Vetch, and J. C. Shaw, as Associates.

"Description of a Sawing Machine for cutting off Railway Bars." By Joseph Glynn, M. Inst. C. E.

Cutting Railway Bars.

The advantage of having the ends of the railway bars cut as nearly square as possible, that they may truly abut against each other, is so great, that many attempts have been made to effect it. The author in this communication describes the method which is adopted at the Butterley Works in the manufacture of the rails for the Midland Counties Railway. In general the ends, rough and ragged as they come from the rolls, are separately reheated and cut off by the circular saw, but the accuracy in this case depends on the workmen presenting the bar at right angles to the plane of the saw. As this cannot be insured, the difficulty may be obviated as follows. The axis of the saws and the bed of the machine, which is exactly like that of a slide lathe, are placed at right angles with the line of the rolls in which the rails are made; the saws are fixed in headstocks and slide upon the bed, so as to adjust them for cutting the rails to the exact length, and are 3 feet in diameter and $\frac{1}{8}^{\text{th}}$ of an inch thick, with teeth of the usual size, in circular saws for wood, and make 1000 revolutions per minute; the teeth are in contact with the hot iron too short a period to receive any damage, but to prevent all risk the lower edge of the saw dips in a cup of water. The saw plate is secured between two discs of cast iron faced with copper and exposed only at the part necessary for cutting through the rail. The rail on leaving the rolls is hastily straightened with wooden mallets on a cast-iron plate, on which it lies right for sawing and sufficiently hot; thus a considerable saving of time, labour, and heat, is effected. The rail is brought into contact at the same time with the two saws, and both ends are cut off by one operation. If the saws be sharp and the iron hot, the 78 lb. rails are cut through in 12 seconds. The rail on leaving the saws is placed in a groove planed in a thick cast-iron plate; thus all warping is prevented. The author then describes certain mechanical arrangements, which are exhibited in detail in the drawing accompanying the communication.

"A description of the Turnbridges on the Herefordshire and Gloucestershire Canal." By Stephen Ballard, A. Inst. C. E.

Turnbridges.

In taking to pieces the old turnbridges on the Herefordshire and Gloucestershire Canal, the author observed that the spikes used to fix the planks down to the carriers had caused the decay of the timber; that the balance weights of stone confined in a box under the planks kept the timber very moist; that the timbers near the ground where there was not a free circulation of air, and the wood wherever it was pierced with iron, were decayed.

In the bridges now described, no spikes are used to fix down the planks, but the planks are held in their places by two flat rods extending the whole length of the planking. The author then describes in detail, by reference to the drawing accompanying the communication, the peculiar method of construction which he has adopted. The planks are $\frac{3}{8}$ths of an inch apart, so that dirt and wet may not lodge in the joints. The bridge is balanced by two stones hung at the ends of the swing poles of about 6 cwt. each. The four principal carriers are supported by three cast-iron bearers fixed to a grooved circle, which rests on cast-iron balls running in another grooved circle. By this construction no planks are pierced with spikes; the box of stones is got rid of, and a free access of air is obtained; and the peculiar causes of destruction to which turnbridges are exposed, are it is conceived in a great measure obviated.

"Description of an instrument for setting out the width of cuttings and embankments of Railways, Canals, or Roads, as particularly applicable to falling or side-lying ground." By Henry Carr, Grad. Inst. C. E.

Setting out Embankments.

The object of this instrument is to facilitate the operation of determining the distance of the outer lockspit from the centre line of a cutting or embankment, by avoiding all calculation, and reducing the usual threefold operation into one. The principle of its construction is the formation of a half cross section, which may be easily altered to suit all cases with regard to base, side slope, and inclination of surface. The construction of the instrument is described in great detail by reference to the drawing accompanying the communication. The author states that he set out a portion of the South Eastern Railway with this instrument, and found it answer exceedingly well. The experience of the first instrument has suggested some improvement in its construction, which is represented in another drawing.

" Observations on the present mode of executing Railways, with suggestions for a more economical, yet equally efficient system, of both executing and working them." By Francis Whishaw, M. Inst. C. E.

Executing Railways.

The author at the commencement of this paper alludes to the principal causes of the great differences between the original estimate and cost of railways. Among these he enumerates the imperfect knowledge of the strata, which occasions the cuttings and embankments to be formed with slopes, which are dangerous, and add to their cost—the imperfect formation of the embankments, especially in clayey soils, which in the opinion of the author ought to be carried up in layers or courses of from 1½ to 2 yards in thickness, sufficient time being allowed for subsidence before the next layer is added—the cost of stations, which in some of the great lines forms a considerable proportion of the whole cost.

The author then proceeds to suggest means for effecting a considerable saving in the original cost of railways, a certain method of preventing accidents by collision, a saving in the annual expenditure, and a better adaptation of the locomotive engine to its work.

With these views, he proposes a single line of rails—that the line should be divided with intermediate engine stations, three on the London and Birmingham for instance, the engines at each being suited to the prevailing gradient of the district. Thus a line of railway may be more easily laid out, as one or two unfavourable inclines will not affect the working of the whole. At each station there must be a small portion of an additional line of rails, and also at other convenient intervals. The mode of working such a line is as follows:—Engines are to start simultaneously in each direction from the terminal and intermediate stations. These engines will pass each other at one of the portions of the double line, and the engine being reversed and taking the other train, will return to the station from whence it started, when another exchange of trains takes place. Thus there is a regular interchange of loads throughout the day, and each engine is confined to its own portion of the line, and it is impossible that a collision can take place. Equal accommodation would be afforded to the public, and the engine man, from being always confined to the same small portion of the line, would be perfectly conversant with every part of it. The saving which would on this system be effected on the original cost is estimated at more than £5000. per mile.

April 23, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected:—T. J. Maude, W. Pearce, S. B. Worthington, as Graduates; J. C. Prior, Lieut. R. C. Moody, R. E., as Associates.

"On Steam Boilers and Steam Engines." By Josiah Parkes, M. Inst. C. E.*

Steam Boilers and Steam Engines.

In a preceding communication† the author had treated of the amount of evaporation in different kinds of boilers in common use; in the present, he treats of their peculiar and relative merits as evaporative vessels; the laws which regulate the amount of evaporation for assigned heated surfaces; and the practical rules whereby the performance of boilers may be tested. The water evaporated and fuel consumed, had been tabulated in the previous communication; the author now gives the dimensions of the several boilers—the area of the grates—the area of heat-absorbing surfaces, and the rates of combustion and evaporation. The connexion of the boiler with the engine as regards the proportion of boiler to engine power, is reserved for consideration in a subsequent communication; the attention is now confined to the influence of the proportions of the parts on the performance of boilers for a given weight of coal. Evaporation may be considered as the measure of the useful effect obtained from any weight of fuel, or, together with the duty done by an engine, the measure of the useful effect of a given weight of water in the shape of steam. The author insists on the importance of ascertaining with accuracy the weight of the water, which in the shape of steam has passed through the cylinder of an engine. The weight of water, or quantity of steam, requisite for producing a given effect or duty, was the subject of continual research by Smeaton; and the basis of Watt's discoveries.

The author being led to make observations on evaporation twenty years ago, soon perceived that the completeness and rate of combustion, the proportion of the grates to the combustion effected upon them and to the whole heat-absorbing surface, were important elements in evaporative economy. These elements, in the author's own experiments at Warwick, where slow combustion was pushed to nearly its furthest limit—in those of Smeaton at Long Benton—of Rennie and Watt at the Albion Mills—of M. de Pambour on the Locomotive Engine, in which intensity of combustion and evaporative power are at their highest limits—of Nicholas Wood on the Killingworth Engine—and of Mr. Henwood, and others, on the Cornish Boiler—are the data for the analysis of the evaporative effects; the true causes of which in the several experiments, the author now attempts to develope.* The authentic facts here recorded of the working of boilers and engines of established credit and notoriety, will enable the employer of any boiler or engine to compare his practice with specimens of acknowledged and well-attested merit.

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* This paper was commenced February 26th, and was continued during four meetings before the Easter recess.

† See Transactions, Vol. 2.

The results derived from the above data are arranged in a tabular form, so as to exhibit at once the relation which any one property and the several parts of the boiler bear to any other, and to the effects produced, the amount and activity of the combustion (to which the author assigns the term *calorific forces*), and the modifications it experiences by the structure and disposition of the several parts.

There are also certain quantities and relations which exert a peculiar influence over the results, which, being rightly ascertained, are exponential or indicative of the practice of each particular boiler; these Mr. Parkes calls the *exponents* of that boiler, and are as follow:—

The quantity of coal burnt under a boiler in a given time,—the quantity burnt on each square foot of grate per hour,—the quantity of water evaporated per square foot of heated surface—and the number of pounds of water evaporated by a given quantity of coal. Besides this, the influence of *time*, that is, the time of duration of any given portion of heat about a boiler, and about equal areas of surface, demands our most attentive consideration, and is specially treated of at the close of the paper. It appears most distinctly, that the boilers tested as to their merit by their respective evaporative economy, arrange themselves in the inverse order of the rate of combustion—the Cornish boiler being greatly superior to all the others when tested in this manner, as well also as in respect if time is selected as the standard of comparison, whereby to mark the scale of descent from the highest point of excellence yet attained in evaporative economy. For this purpose, then, the Cornish results are considered as unity.

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* The author has been unable to obtain any similar data for the *Marine Boiler*.

The value of the exponents for the Cornish, Wagon and Locomotive Boiler respectively, are collected together in the following Table, which will serve to shew at one glance the respective values of the Boilers on this comparison.

Boiler.	lbs.	
Cornish	1·0.	of Coal burnt under one boiler in 44·08. seconds.
Wagon*	1·0.	of ditto ditto in 16·57. ditto.
Locomotive ..	1·0.	of Coke ditto in 6·45. ditto.
Cornish	3·4.	of Coal burnt on each square foot of grate per hour.
Wagon	10·7.	ditto ditto
Locomotive ..	79·3.	of Coke ditto
Cornish	1·0.	of Water evaporated by 1 square foot of heated surface per hour from 212°.
Wagon	7·1.	ditto ditto
Locomotive ..	12·0.	ditto ditto
Cornish	11·8.	of Water evaporated by 1 lb. of coal from 212°.
Wagon	8·8.	ditto ditto
Locomotive ..	7·2.	ditto 1 lb. of Coke, ditto
Locomotive ..	5·4.	ditto 1 lb. of Coal, ditto

The Cornish Boiler possesses some peculiar advantages, both as regards structure and the practice of slow combustion, since, by the former, great strength is attained, and, by the latter, time is given for the complete combination of air with the heated fuel, for the transmission of heat through the metal, and for the escape of the steam through the water. The plates of the Cornish boiler are usually ½ an inch thick, whereas those of a low pressure boiler are usually ¼th to $\frac{5}{16}$ths of an inch thick; thus a much larger extent of surface is necessary to transmit a given quantity of heat in a given time in the former than in the latter case. The Cornish Engineers allow seven times as much surface as in the general wagon boiler practice, for the evaporation of equal weights of water in equal times, and twelve times as much as in the locomotive; from which there is a gain of from 30 to 40 per cent. in the former, and of 64 with coke and 100 with coal in the latter case.

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* The results for the Wagon Boiler are the mean for eight boilers.

The Wagon boiler has great disadvantages of structure, being ill adapted to resist internal pressure, liable to collapse, and greatly affected by incrustation. According to the above table, which exhibits the mean of eight experiments, the combustion is 2⅓ times more rapid per boiler, and 3 times more rapid per square foot of grate per hour, and the rate of evaporation is 7 times greater than in the Cornish. The loss of heat, the Cornish being unity, is 24⅓ per cent.

The construction of the Locomotive boiler is so very different from that of every other species of evaporative vessel, that no strict analogy can be drawn betwixt it and any other. From the above practical results it appears, that the rate of combustion per boiler is nearly 7 times, and per square foot of grate per hour 23 times more rapid—that the rate of evaporation from equal surfaces 12 times more rapid than the Cornish Boiler—the loss of heat, the Cornish being unity, 51 per cent.

The author discusses at length the varying circumstances connected with different boilers, and the corresponding influence on the above results, and particularly the system of management by which he was enabled with a Wagon boiler to approach the Cornish results. The table accompanying this paper will frequently enable the intelligent employer of a boiler to ascertain the best proportion of parts, and the best practice. For, having decided on the quantity of steam he requires, he knows the quantity of fuel which will generate it if he adopts the measures of surface and proportions of parts, which have given relative effects; or he can ascertain whether his present practice be good or defective. Notwithstanding the great stride which has been made in the economy of fuel by the Cornish Engineers, the sources of waste are still great, and we may hope for great advances in evaporative economy, when combustion as a science and practical art has received the attention which it merits.

The effect of a different practice as regards rapidity of combustion and arrangement of parts, entirely disturbs the relation betwixt boilers of equal surfaces; the table shews an almost perfect identity in the total, the radiant, and the communicative areas, between the mean of eight experiments on the wagon and eleven on the locomotive boiler, and the locomotive boiler would present between 3 and 4 times greater surface to absorb the heat generated on the grate than the wagon, if the rate of combustion were the same in both, but the rate of combustion is seven times more rapid in the locomotive, and consequently the locomotive does not offer one-half the surface of the wagon boiler for the absorption of the heat produced from equal weights of fuel in the same time. The result of this discordant practice is a loss by the locomotive of $\frac{1}{3}$rd of the heat which is realized in the wagon boiler; that the rate of evaporation from equal surfaces is augmented in the locomotive by 65 per cent., so that the increase of evaporative power is attended by a sacrifice of 33 per cent. of fuel.

The locomotive possesses peculiar advantages in the thinness of the metal composing the tubes, and the sub-division of the heat, but these are more than neutralized by the exceedingly short period of the duration of the heat, from any given quantity of fuel about the boiler. This most important subject of time is discussed in a series of propositions based on the following principles:—The structure of the boiler and its mode of setting occasion the heat to travel greater or less distances, and over very unequal extents of surface in equal times, and the value of time will be appreciated by referring it to the rate of combustion, to the distance passed over by the products of combustion before they quit the boiler, the time in which the heat traverses the boiler, and to the period of the duration of the heat about equal areas of surface. These remarkable elements give rise to eleven propositions, which are fully discussed and illustrated by tabulated results. The peculiar action which takes place on the metal of the boilers is indicated by the phrase *intensity of the calorific action,* since there are involved many actions which are entirely independent of the temperature of the fire. The relations furnished by some of these propositions are facts as regards the relative action of the fires, and furnish appropriate measures of the effects of different systems of practice on the durability of the boiler.

The preceding abstract having been read, Mr. Parkes remarked there were so many elements to be taken into consideration—the evaporation was affected by so many circumstances—there were so many things left untold—that he hoped some of the many who were capable of making experiments would give their assistance. Every day's work was an experiment which ought to be carefully registered. He had great difficulties on many points, particularly with respect to the locomotive boiler and the thinness of the heat-absorbing surface. It had been stated on a preceding evening that Dr. Ure had proved, if two vessels of equal size, the one of thin and the other of thick metal, be placed in a sand bath, there will be more water evaporated in a given time by the thicker than by the thinner vessel. This was very extraordinary, since he thought that 25 per cent. would be lost in the locomotive boiler if the tubes were of double the thickness.

The effect of thickness of the material was evident in the experiments which every boy has made with the paper boilers over a candle. The real cause of the destruction of boilers is the application of heat to thick surfaces. Another subject of peculiar importance is the temperature at which the heat leaves the boiler and enters the chimney. He had made experiments on this at Warwick, and proved that he could not boil the water in a vessel at the top of a chimney 60 feet high; the temperature never exceeded 180° F. It was argued that more of this heat could not be used, but the Cornish engineers had shewn that to be an error, having surpassed his results.

Another subject is the constant loss of heat by radiation; he had attempted to ascertain this with Mr. Wicksteed; the boilers at Old Ford were covered with cinders, so that but little radiation would take place but from the front or bed; still the quantity of heat which goes off is considerable, and one great source of waste. They had observed with great care the quantity of coal requisite to keep the boiler hot; this would furnish some measure of the loss due to radiation.

Blocks for Railways.

The attention of the meeting having been called to M. D'Harcourt's artificial granite for railways, blocks, and other purposes, Mr. Rastrick remarked that he had about a month ago laid down blocks of the Scotch Asphalte, two feet square, on a portion of the Southampton Railway. The sleeper was put in while the block was formed. It was usual to bore holes and to fix the chairs by bolts; he had wished to ascertain how far the blocks would stand the driving in of the bolts, without any boring; they bore this without any apparent injury, and he thought these blocks, weighing about 3¾ cwt. would answer the purpose, better than blocks of other materials.

April 30, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected: Edward Cottam, as a Graduate; Isaac Dodds and Edward Cressy, as Associates.

"On the supply of Water from Artesian Wells" By R. W. Mylne.

Artesian Wells.

Artesian wells, so called from their having been originally adopted in the province of Artois, by the Romans called Artesium, are usually made by boring vertically through a deep stratum of clay into one of sand, which generally contains water. The water will rise to a considerable height, depending on the elevation of the point at which the sand stratum crops out from under the bed of clay. The London basin is peculiarly adapted for these wells, as on the large bowl of chalk is a thick lining of sand, supporting a deep bed of clay, known as the London blue clay. On boring into this sand, or into the chalk, the water rises to various heights, and it has been thought that an abundant supply for the metropolis might thus be obtained. With the view of ascertaining what dependence can be placed on this source, the New River Company sunk a well, the details of which form the subject of this communication. Before entering on these the author mentions several instances of wells supplied from the *sand springs* in various parts of the metropolis, and other parts of the country. In most of these the supply has been so affected by neighbouring wells, or the upper ground and buildings have been so endangered by the large cavities produced in consequence of the fine sand being pumped away, that the wells have been abandoned. Several remarkable instances of the effects of this subsidence are detailed in this communication. Experience thus appearing to shew that little dependence can be placed on the sand springs, it has been suggested to sink through into the chalk; but the supply from this source also is affected in a remarkable manner in various cases.

The author then proceeds to give the particulars of the sinking of the well in the Hampstead Road. In March, 1835, an excavation, 20 feet in diameter, and 23 feet deep, was made; the sides were supported by wooden curbs with puddle at the back, so as to shut out the land springs. At the bottom of the curbs, just in the blue clay, a cast-iron footing was added, and a brick shaft of 12 feet 6 inches diameter carried up to the surface of the ground. The excavation was continued for 59 feet through the clay, steined with 9 inch brickwork in cement, iron rings were placed at every 8 feet of the brickwork, and of a greater diameter than the shaft, and projecting into the clay a few inches so as to support the shaft in its progress; the brickwork was continued through 57 feet only, leaving 2 feet of clay for a foundation. The excavation was now reduced to 10 feet 9 inches, for the purpose of introducing cast-iron cylinders formed of six segments, 6 feet in length, united by bolts through flanches on the inside, and leaving 9 feet 9 inches clear diameter. These being joined together were forced down by hand screws, as the sinking continued through the 2 feet of blue clay and through 10 feet of soft mottled clay, at the bottom of which water appeared.

The well was kept dry by an engine and two 8 inch pumps in two lifts, and the sinking continued for 8 feet, through a bed of fine brown sand. Cavities were now discovered behind the cylinders, which were forced out of the perpendicular by the unequal pressure, and became completely jambed. A second set of cylinders was now prepared, and the sinking continued for 26 feet through the remainder of the dark brown sand, soft mottled clay, a thin layer of pebbles and black sand closely embedded, and 4 feet 6 inches of dark brown sand. Cavities again formed at the back, and the cylinders became jambed.

A third set of cylinders was now prepared of 7 feet 4 inches diameter, and the sinking continued through 7 feet of dark brown sand, and 5 feet of dark quick sand, when they again became jambed. During the latter portion of the work great difficulty was experienced from the blowing of the sand, often to the height of 6 feet; this occasioned large cavities behind the cylinders and the brickwork; several segments of the former were broken at their vertical flanches, and the lower part of the latter was much cracked. A large cavity also was formed at the back of the brick shaft about 60 feet from the surface. The settlement of the ground at the surface was so extensive that the pumping was discontinued until the plan suggested by Mr. Simpson, of continuing the sinking with the water in the well, was adopted.

For this purpose, in August, 1836, a wrought-iron cylinder, 62 feet long, and 5 feet 10 inches diameter, formed of boiler plate, was lowered to the surface of the sand, which had become consolidated under the pressure of the water, and was removed by an instrument called a miser, which holds about two bushels. The cylinder was forced down by hand screws on its upper edge, through the remainder of the quick sand stratum, through a bed of sand with flints and pebbles, and through a bed of chalk and flints, into the chalk to a depth of 12 inches. The water and sand being now shut out, the well was dried, and in March, 1837, the sinking continued in the usual manner to a total depth of 183 feet, the chalk being sufficiently indurated not to require lining. The water now increased considerably, and the chalk was excavated to an enlarged diameter below the bottom of the wrought-iron cylinder, for the purpose of forming a brick footing. On the top of this was placed a broad cast-iron ring, upon which rested a series of cast-iron cylinders of a clear diameter of 4 feet 7 inches, which were introduced within the wrought-iron tube, for the purpose of strengthening it, and guarding against the admission of sand in case of its failure from corrosion.

In February, 1838, the works being complete, the pumps of 12 inches diameter were introduced in two lifts; and in August, 1838, when the springs were short, and in March, 1839, when the springs were at their best, an experiment of two weeks was made; the result of the former was 14,898, and of the latter, 30,499 cubic feet per day of 24 hours. The total expense of the well was £12,412. 14s. 1d.

The paper is accompanied by a copy of the report of James Simpson, Esq. in which the plan adopted for the completion of the works is recommended. Mr. Simpson details the difficulties which had been met with, and particularly the extensive subsidence of earth caused by the removal of the sand. This far exceeded the quantity due to the contents of the well at the lower sand stratum, and the subsidence proceeded most rapidly when the water was pumped out of the well. The experience of wells near the metropolis shews that the springs in the chalk are much more abundant than in the sand, but in order properly to take advantage of them, adits must be driven to collect the water from the fissures in the cavernous structure of the chalk. The report proceeds to speak of certain methods of securing the present works, and of prosecuting them by either driving an iron pile curb or sinking iron cylinders cast in entire circles. The former could not be recommended, as a considerable further subsidence would be the consequence, and the shaking of the ram would endanger the works. The latter method might be adopted: it is performed with common boring rods and tools, the shells or buckets are fitted with valves opening upwards, and the material is raised by them with the greatest ease. When the cylinders become set, or when they do not sink in proportion to the material removed, they are slightly jarred by a heavy sledge hammer. The advantage of keeping thewater in equilibrium inside and outside the cylinders is very great, and the method has been in many cases peculiarly successful.

The paper is accompanied by a section of the works and the strata, and by drawings of the various tools employed.

Mr. Brunel stated, that the succession of the strata here described was nearly the same as they had met with at the Tunnel.

Mr. Simpson remarked, that the greatest caution was requisite in drawing conclusions respecting the strata in one part of the metropolis from what was known of it in another part. At Lambeth, for instance, in the same shaft, there might be gravel on one side and sand on the other, and the London clay is here about 32 feet below Trinity high-water mark: near Chelsea College the London clay is met with at the depth of 38 feet, after passing through sand and gravel; and a little farther on, in the King's Road, the clay is reached without passing through any sand, and in this locality the chalk is touched at 245 feet below Trinity high-water mark. It was a remarkable fact that they should have reached chalk at so small a depth in the Tottenham Court Road well. The alterations in the strata are so great, that no one who has had any experience of wells will venture to infer from one place what will occur at another. The engine employed at this well was a twenty horse, and worked at an expense of about £2. 7s. per 24 hours. This, however, is a very small part of the expense of supplying water to houses, as the water has to be raised to the houses, and the cost of pipes must be included. It was not very intelligible how water was to be raised from so many feet below high-water mark, and supplied at the same cost as water taken from the Thames at the level of high water.

May 7, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected:—C. S. Russell, as a Graduate, and H. C. Bingham, as an Associate.

"The Sewage of the City of Westminster, described and delineated." By John E. Jones, A. Inst. C. E.

Sewage of Westminster.

This communication, consisting of a large map, plans, sections, and tables, with a description of the Sewage of the City of Westminster, is prepared in consequence of the Council having directed attention to the great importance of this subject.

The author having remarked on the magnitude of the subject, on the defective state of the legislative enactments, and on the necessity of employing in works of such importance the most eminent professional assistance, as has been recently done by the Commissioners of this district, directs his observations to the following subjects:

1.—The history of Sewage, embracing the progress of legislation on Sewage or Drainage to the present time.

2.—The principles of Drainage as applied to Westminster in particular.

3.—An explanation of the Map, Plans, Sections, and Tables.

1.—In the earlier statutes and writers on this subject the word sewage or sewerage is identical with drainage, as appears particularly from the act of Henry the Eighth, which is the general sewage act by which the commissioners of sewers are now guided, being for the most part applicable to fen land drainage. The metropolis and adjacent districts, comprehended within a distance of ten miles from the Post Office, are divided into seven distinct and independent trusts, whereof five are administered by local acts, the other two by the general sewage act first alluded to. The sewers falling into the Thames within two miles of London, are, by the 3rd of James the First, placed under the commissioners of sewers, and the 47th of George the Third defines and declares the powers given by the act of James. This statute, passed in 1807, was not acted on to any extent till 1813, the interval being employed by the commissioners in requisite arrangements. The difficulties with which they had to contend, owing to the rapid demands for additional drainage, the defective state of the old works, and other causes, being considered, the conclusion of the Committee of the House of Commons,—"That whatever the defects of the laws of sewers may be, they appear to have been administered of late years with good faith and integrity on the part of the commissioners,"—appears fully justified.

2.—The principles of drainage, or of conducting the superfluous waters to their proper outlets, are few and simple; but in the drainage of a town, the masses of buildings of all ages and all kinds of various levels, the concentrated mass of filth, and the numerous conflicting interests, conspire to make the establishment of an efficient system of sewage one of the most difficult, as it is one of the most important, objects to which the skill of man can be directed. One great difficulty has arisen from the commissioners not being invested with powers enabling them to originate new lines of sewers, but being confined to improving those that exist, and controlling the construction of new ones. A large portion of Westminster is below the level of high water, and the drainage of buildings being optional on the part of the builder, there consequently exist insulated houses and districts of loathsome filth, for want of sufficient compulsory powers on the part of the commissioners. The obvious remedy for these evils is, to give powers to the commissioners of sewers within their districts to compel every person to drain his property in an effective manner under their approval, and to form such new main lines as circumstances may render necessary, and to impose general rates for their maintenance.

3.—The large plan or map is a delineation of the city of Westminster, compiled from original surveys in the possession of the commissioners of sewers, and laid down to a scale of one inch to two hundred feet; the boundaries of the city and of the several parishes, of the main lines of sewers, and of the collateral sewers, are marked with different coloured lines, so as to be readily distinguished; the sewers of different dates are also distinguished by particular colours; and the whole plan is divided into districts, and coloured in various ways, so that a most comprehensive and distinct idea may be at once obtained of the principal or main sewers by which the waters of this portion of the metropolis are received. This plan also exhibits a section of the Regent's Park Tunnel, and of the King's Scholar's Pond Sewer.

The Book of Sections consists of upwards of one hundred sheets of tables and drawings, shewing the districts drained by the main sewers, plans and sections on an enlarged scale of all the main sewers, with the elevations of their several outlets or falls into the Thames. The tables present, in a condensed form, every information respecting the main sewers; as, the length of the sewer, the levels of the sewer and of the ground; the dimensions; the number of acres drained by it, and the date of its construction. The author has also added the regulations of the Commissioners of Sewers of the Westminster district respecting the construction of main sewers, as to their transverse sections, fall and rate of current, materials and mode of construction, and provisions for public safety and convenience, during the progress and after the completion of such works.

New Pentograph.

Professor Wallace exhibited a pentograph of a novel construction, by which drawings may be copied or reduced and etched with great facility. Mr. Macneill bore strong testimony to the advantages of this construction over every other which he had seen, and stated that it had enabled him to finish a plan in 3½ hours, which he could not have finished with an ordinary pentograph in less than 12 hours.

May 14, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected:—the Right Hon. the Earl of Orkney, and E. Lomax, as Associates; and W. Tooke, as an Honorary Member.

"A description of the Coffre Dam round the 13 and 14 feet piers of Westminster Bridge." By Frederick Pollock, Lieut. Madras Engineers.

CoffreDam Westminster Bridge.

It was the intention of Labelye, the builder of Westminster Bridge, that none of the foundations of the piers should be at a less depth than 5 feet below the surface of the bed of the river, but the effect of the removal of old London Bridge, and of the increase of the average difference between high and low-water, had in 1836 lowered the bed near the pier on the eastern side to within 18 inches of the platform, being 3 feet lower than in 1829; and but for the works done under Mr. Telford's direction by Mr. Swinburne, and those which are now going on under the direction of Mr. Walker and Mr. Burges, the piers would have soon become undermined. Labelye is supposed to have been deterred from attempting to lay the foundations by a coffre dam, from the difficulty of keeping it dry and of reaching the bottom; this is, however, now shewn to be a groundless alarm, as one has been constructed which is so tight that two men can keep it perfectly dry.

The Coffre Dam, the construction of which forms the subject of this communication, is formed round the 13 and 14 feet piers at the west end of the bridge, for the purpose of securing the foundations and repairing the damaged arch stones. Previous to the commencement of the work fender piles were driven 10 feet into the bed of the river, and are 5 or 6 feet higher than Trinity high-water mark; a trench was then dredged in the intended line of the coffre dam to the level of the highest caisson; the first gauge pile was driven on the 14th of July, the first sheeting pile on the 24th, and the water stopped out or the coffre dam completed in the short space of seven months.

The author then details the dimensions of the timbers and the construction of the various parts of the dam as represented in the drawing, accompanying the communication. There are about 40,000 cubic feet of timber in the dam. The mean depth of the mud in the dam, the water being let out, was from 4 to 5 feet; underneath the mud, at about 3 or 4 feet above the caisson, is a stratum of red gravel of an average depth of 15 feet, and below this is clay. The weight of the piers has bent down the caisson as shewn in the drawing, but the timbers are still sound and good. The pressure against the dam, at an average high tide, is 1775 tons.

The President remarked, that there was frequently considerabe ambiguity in the use of the terms, *rise of the tide*, and misconception as to the effect of the removal of old London Bridge upon the rise and fall of the tides. The water falls lower by between 3 or 4 feet, that is, by the height of the sill, which was removed, but the difference of level of high-water is very small, not more than a few inches. The old London Bridge caused a sort of weir, varying from 8 to 18 inches, as the water ran up, but depending in a great measure on the quantity of upland water which was coming down; sometimes there was scarcely any difference of level on the two sides of the bridge.

Straw Coke.

The President presented from Mr. Pryor a specimen of Straw Coke, and Mr. Pryor stated the method of making it to be exceedingly simple, though but few attempts were successful. A mass of straw saturated with water is thrust into the farthest corner of the coke oven, previous to the oven being charged; the damper being kept close the smoke impregnates the straw, and it endures the heat for 48 hours: it is well sprinkled with water immediately on being withdrawn. Mr. Lowe described its production as the effect of smothered or subdued combustion. The carbon becomes deposited on the straw saturated with moisture, and placed at the part of the oven least exposed to oxygen. The difficulty is to account for the oxygen of the atmosphere not combining with it when hot; there must be some means of protecting it from the oxygen of the atmosphere on its being withdrawn, which is to him yet a mystery.

May 28, 1839.

The PRESIDENT in the Chair.

Diving Bell.

Colonel Pasley stated the result of some experiments which he had made with a diving bell in the Thames and in the Medway. The common rectangular diving bell, suspended from a vessel in a very strong tide, was completely swept under the boat, and in some other cases it swung round half and half, or was twisted considerably out of its proper position. He attached boat-shaped ends. and on descending at the half ebb of a strong flood tide the bell was perfectly steady. He should think a bell fitted in this manner would be exceedingly advantageous for going alongside of wrecks. He should recommend the ends to be moveable, and if the wreck were athwart the tide he should have only one end put on, and bring the bluff end against the vessel. An experienced diver had informed him, that in the current of the Danube, running seven knots an hour, the bell vibrated tremendously. Since this arrangement had occurred to him, he discovered that a similar one had been proposed to the "then Navy Board," about twenty years ago, by Mr. W. S. Smith, who had been employed under Mr. Rennie, but it does not appear to have been tried. Colonel Pasley promised the Institution a more detailed account of his experience on this important subject.

Coke and Peat.

Mr. Parkes stated, that he would take this opportunity of the presence of Mr. Williams to lay before the meeting some specimens of French Peat, which had been alluded to on a previous occasion.* One of the specimens was that obtained by allowing the particles to come within the influence of the natural forces to which the atoms are subject. The slutch as dredged up from the bottom of the streams, in a state of great comminution, was put into moulds, and, contracting as it dried, acquired considerable density. This was an instance of density due to gradual drying; the density became doubled by this process. Mr. Parkes presented a specimen of coke from compressed peat; this Mr. Williams would explain, as he had taken up the subject where every one else had left off, and had succeeded in producing density by mechanical means, at a moderate cost, and, by carbonizing the mass, in getting rid of the volatile

* *Minutes*, Jan. 8, 1839.

particles, which are injurious as a fuel; he thus produced an extremely valuable coke.

Another specimen was of the incrustation on the interior of a gas retort; it was a coke of extreme density and of great value for some purposes, but for what was a secret. This deposition accumulates until the interior of the retort is almost filled up, leaving no available space for the charge. The retorts are bought for the sake of this coke, which is a perfect carbon. A thin coating of carbonaceous matter, which would otherwise be carried off in the gas, is deposited each charge.

Mr. Lowe was not aware of the uses to which this coke could be applied; but it was of extreme disuse to the gas-makers; he believed, however, that it was used to produce an intense heat. It is sometimes stated to be a carburet of iron, but a portion from the centre of the mass shews, on being tested, not the least trace of iron. It arises naturally in the process of gas-making, and the rate of its deposition depends on the temperature; as in those retorts which have a tendency to become too hot the deposition goes on exceedingly fast. There were many curious facts connected with its deposition; that in a horizontal part is stratified in concentric layers. The upper portions will be perfectly sectile and form admirable crayons, that at the lower part will scratch glass; it decreases in density from the bottom; a portion of the sides partakes of both qualities. He suspected, that a large quantity was sold as black lead.

Mr. Williams remarked, that there were two kinds of peat, the one having a density due to impurities; this is useless for all purposes of metallurgy. But for the purest carbon, the upper surface of the moss must be used, and an artificial density must be communicated to it; it is only in this manner that a dense and pure coke can be obtained. The peat having this artificial density is carbonized, by which all the volatile matter useless in combustion is driven off, ground, and then being mixed with a bituminous matter the operation of nature in the production of various species of coal may be closely imitated.

June 4, 1839.

The PRESIDENT in the Chair.

The following were balloted for and elected: Samuel Castle Gant, as a Graduate; and Earl de Grey, as an Honorary Member.

"On the Dimensions and Performances of the Archimedean Steamer." By George Rennie, F.R.S., &c. &c.

Screw Propeller.

The method of propulsion, by means of a horizontal spiral screw, applied by Mr. Smith in the Archimedes has frequently been attempted, and many authors have expressed opinions upon its applicability. Among others Mr. Tredgold, in his work on the Steam Engine, expresses a favourable opinion of this method of propulsion, on account of the action being completely under water and of the compactness and uniformity of the motion, objecting only to the mode of communicating the motion, and the resistance the parts will offer that are applied for that purpose. He gives also a formula, from which it results, that the larger the diameter, and the less the pitch of the screw, the greater will be the proportion of the effective power on the vessel. The obliquity of its action has been advanced as an objection, whereas the operation is analogous to the action of a screw entering or leaving a block of wood, the less resisting medium yielding in proportion to the comparative resistances offered by the vessel and the propeller respectively.

The dimensions of the large screw were 7 feet in diameter and 8 feet in length, with an area of 38 square feet, after deducting the area of the spindle; consequently, if the resistance of the screw exceeded greatly the resistance of the vessel, very little if any loss of progression would take place. The midship sectional area is about 100 square feet; and since the reduction of the resistance of a well-made vessel, according to the experiments of Colonel Beaufoy, as compared with a flat disc forced through the water, has been found on the average to be about $\frac{1}{17}$, the actual midship section will be $\frac{100}{17} = 5{\cdot}8$, or say, with friction, 6:—the large screw, therefore, having a surface of 38 square feet, or more than 6 times the surface to propel the vessel.

The small screw was 6′-6″ diameter, 7′-6″ long, 33′ area, which by the same reasoning yields $\frac{33}{6} = 5{\cdot}5$ for the ratio of the smaller propeller to the sectional area.

The relative resistances of a circular disc 7 feet in diameter and a globe of similar diameter, at a velocity of 8 miles an hour, are as

$4\frac{1}{3}$ to 1. It will not therefore be too low an estimate to take $\frac{1}{20}$ instead of $\frac{1}{17}$ on account of the favourable figure of the vessel. The velocity is ascertained by multiplying the length of the screw into the number of revolutions: the large screw making 80, and the smaller screw 130 to 135, the speed should be 7 and 10 miles respectively. By the log the actual speed was 9 miles; the loss consequently only $\frac{1}{10}$, whereas the average in the common paddle wheel varies from $\frac{3}{10}$ to $\frac{4}{10}$. The greater hold obtained by the propeller will be perceived from the respective depths of immersion, that of the paddle wheel being 18 inches, and that of the screw being 4 feet under the water. The most important application of the propeller is for vessels of war as the machinery is out of range of gun-shot, the engines below the level of the decks, and protected by the coal bunkers on either side, 7 feet in thickness in the Archimedes. In the voyages to Ramsgate and Portsmouth the average speed was 9 miles an hour. Mr. Rennie is of opinion, from the results of his own experiments upon the subject, that this method of propelling vessels will ultimately be applied to a considerable extent.

The dimensions of the Archimedes are:

Length of vessel	105	feet.
Breadth	$20\frac{2}{10}$	„
Depth of hold	$12\frac{5}{10}$	„
Burthen in tons	230	
Length of engine room . . .	38	feet.

The vessel draws 10 feet water, and carries three masts and sails schooner fashion.
Power of engines collectively, 90 horses.
The crank shaft is driven from the connecting rods attached to the piston rods of each cylinder.
Length of stroke 3 feet; 30 strokes per minute.

The speed of the propeller is gained by wheel work, and communicated by a shaft passing beneath the cabin floor and traversing the sternpost of the vessel. The diameter of the screw is now reduced to 6 feet, the length 8 feet, and consists of spiral oblique wrought-iron plates attached by arms to the shaft. The weight of the engines, boilers, and machinery, is about 64 tons.

Upon the first trial of the Archimedes the log indicated 8·5 miles per hour, the vessel readily answered to the helm, and performed the several movements required. Upon the second trial the vessel left the Brunswick Dock at flood tide, and reached Gravesend (21 miles) in 1° 45′; upon the following day she arrived at the

Nore (22 miles), with the tide, in 1° 40′; and subsequently towed a yacht of 50 tons up the Medway, with scarcely diminished speed. From Sheerness the Archimedes reached Ramsgate (45 miles), in 4° 30′; the screw was here reduced in diameter, and on leaving the harbour against a heavy tide and N. E. wind she made five knots, and gave great satisfaction; the sails were set upon rounding the Foreland, and the speed was increased to 9, 9½, and 10 miles per hour, or 14 miles with the tide. Upon her second voyage to Portsmouth the measured mile was performed with the tide in four minutes. The weather was unfavourable, and the wind high; the distance (194 miles) to Portsmouth, occupied 21 hours; her average speed upon the return to London was 9 miles per hour.

June 11, 1839.

JAMES SIMPSON, Esq. in the Chair.

The following were balloted for and elected: Richard Griffith, as a Member; and Thomas Penson and Robert Aytoun, as Associates.

"On Warming and Ventilating Public Buildings and Apartments, with an account of the methods which have been most successfully employed for ensuring a healthy state of the Atmosphere." By Charles Hood, F. R. A. S.

Warming and Ventilation.

The author first treats of the constitution of the atmosphere; the artificial changes produced in it, and the effect of these changes on animal economy. The researches of chemists shew that in atmospheric air, uncontaminated by respiration or other means, there exists from 21·1 to 20·5 per cent. of oxygen, 78 per cent. of nitrogen, $\frac{1}{10}$ per cent. of carbonic acid, and a small quantity of aqueous vapour. Besides these there are many foreign matters insensible to chemical tests, but quite sensible to our organs, whereof many being easily decomposable by heat, are resolved into their constituent gases; to this fact is to be referred the wholesomeness and pleasantness of some artificial systems of heating, or the contrary. The hygrometric condition of the atmosphere is most remarkably affected by change of temperature, as the quantity of vapour in air of 52° F. may be estimated at $\frac{1}{160}$th of the weight of air, at 59° F. at $\frac{1}{80}$th, and at 86° F. at $\frac{1}{40}$th; when then the temperature of the air within the room is considerably above that of the air without, this increased capacity for moisture is productive of effects prejudicial to the health. Moreover, if iron surfaces of too high temperature be present, the vapour may become decomposed, its oxygen combining with the iron, and the hydrogen becoming diffused through the atmosphere. Consequences prejudicial to health from these causes have been repeatedly experienced in rooms heated by a hot air cockle; these effects are not peculiar to the hot air cockle, but will result in a greater or less degree whenever artificial warmth is produced from iron surfaces, the temperature of which much exceeds 212° F. The dryness of the air may in some measure be remedied by moisture, distributed artificially, but the effects from the decomposition of the particles of matter cannot be obviated by any artificial means. The system of Mr. Bernhardt is peculiarly open to these objections, as the pipes nearest the fire must become intensely heated; as also the stoves introduced by Dr. Arnott; since, independent of the difficulty of keeping down the temperature of the metallic surface, carbonic oxide is produced from the coke, and carburetted hydrogen is also formed in the stove. The gas stoves are also open to the same objections; moreover the quantities of water, of nitrogen, and of carbonic acid gas evolved by the combustion of the gas are extremely deleterious. In the latter case aqueous vapour will be in excess, and consequently the due quantity of perspirable matter is not carried off from the lungs and skin, the injurious effects of which have been clearly established by M. Quetelet in his work on man. The injurious effects of an excess of nitrogen and carbonic acid gas are too well known to require comment.

The author next treats of the best methods of warming buildings in order to secure a healthy state of the atmosphere; and having shewn the disadvantages of applying heat directly to any surfaces, he points out the method of applying it indirectly, as by steam or hot water, contained in iron pipes: the latter is more economical and simple, affords greater permanence and equality, admits of a lower uniform temperature, and any form of heating surface. The temperature of the metallic surface rarely exceeds 180° F. and never reaches 212° F., which is too low to decompose in any appreciable degree the organic matter contained in the air. The only effect is to increase the capacity of the air for moisture, which is readily obviated. The surface which is intended to distribute the heat should be a good conductor and radiator, and the material which presents this combination in its highest degree is iron: the amount of heating surface which will be required depends on the building to be warmed, and on a great variety of circumstances; but as an approximate rule it may be laid down, that for a church or similar public building the cubic contents of the building divided by 200 will give the number of feet of surface requisite for a temperature of from 55° F. to 58° F. in the coldest weather ordinarily experienced in this country. The form of the heating surface is immaterial as regards the action of the apparatus, but the time requisite to obtain a given temperature, and the permanence of that temperature, depend on the mass of heated matter; the relative times of heating and cooling being inversely as the mass divided by the superficies. A rapid circulation of the water may be obtained by increasing the elevation of the pipes above the boiler, but it is considerably influenced by any alterations in the bore of the pipes. One great advantage in this apparatus is its perfect safety, as the water at some point is always open to the atmosphere, whereas in the system of hermetically sealed pipes, containing steam or hot water under a pressure of from ten to fifty atmospheres, this security can never exist.

3.—The author lastly treats of ventilation; a subject of the greatest importance, independent of the changes already alluded to as produced in the atmosphere by overheated surfaces, since all air respired from the lungs is found to have lost a proportion of its oxygen, and to have acquired a proportion of carbonic acid gas and vapour, and the quantity of air which will require to be changed may be taken as 3½ cubic feet per minute for each person a room contains. The author dwells at considerable length on the physiological effects consequent on these changes, and details several striking instances of the great advantages resulting from improved ventilation, in places which had previously been unhealthy. All ventilation may be placed in one of two classes, the natural or the mechanical; in the former, the excess of temperature of the air is the *primum mobile* of the efflux, and the rapidity of the discharge may be much increased by artificially raising the temperature of the discharging pipe. Ventilation by mechanical means, as by pumps, or by fans rotating with a great velocity, may be most advantageously employed, wherever mechanical power is used for other purposes; the great efficacy of this latter mode is proved most unquestionably by the experience of the manufacturing districts. The former method has recently been tried on a very large scale at the House of Commons, and it is calculated by Dr. Ure that 38 times more fuel is expended in producing the same effect by chimney draughts than by mechanical power. It appears, however, that the natural method of ventilation, by the spontaneous effusion of the heated air, through openings in the ceiling, is the best calculated for ordinary purposes; but that in all extraordinary cases ventilation by some mechanical means is the only economical and efficacious method.

"Experimental Researches upon the cost of the Light afforded by different Lamps and Candles." By Andrew Ure, M.D., F.R.S., &c. &c.

Hot Oil Lamp.

The author having instituted a series of experiments to determine the advantages of Mr. Parker's new hot oil lamp, adopts as the standard of comparison the French mechanical lamp, in which the oil is raised by machinery, so as continually to overflow at the bottom of the burning wick. The relative illumination was determined by the well-known method of the equal intensity of shadows, and verified by that adopted by Professor Wheatstone, namely, by the relative brightness of the opposite sides of a revolving ball.

One peculiar feature of the new lamp is its bell-mouthed glass chimney, above which is a chimney of iron, with a parted diaphragm for the purpose of causing a certain portion of the heat of the flame to reverberate against the interior cylindric cavity of the oil cistern. The bell mouth is formed in a mould, and is far better suited for producing a steady flame than the rectangularly contracted chimney of the mechanical lamp. The intensity of the shadows from the mechanical lamp and the hot oil lamp, of a wire a few inches long and of the thickness of a crow quill, was equal, at a distance of 10 and 11 feet respectively; their relative illuminations being as the squares of these are, as 100 and 121 respectively, and the consumption of the best sperm oil was 15·2 and 11·6 grains per minute; the relative cost of illumination for this oil would thus appear to be 50 per cent. in favour of the new lamp. On trying Southern whale oil the cost of illumination appeared to be about one-third that of the mechanical, and one-half that of the hot oil lamp with sperm oil. The author tried many other substances, and, comparing the various illuminations, concludes that the hot oil lamp with Southern whale oil affords an economy of light nearly 12 times greater than stearine or German wax candles, 7½ times greater than tallow mould, 11 times greater than cocoa nut, 8½ times greater than Palmer's, 17½ times greater than spermaceti, and 18 times greater than wax candles.

The author had also compared the illumination produced by one of the Fresnel's Lamps deposited at the Trinity House. The lamp consists of four concentric circular wicks, placed in a horizontal plane, the innermost being $\frac{7}{8}$ths of an inch, and the outermost $3\frac{1}{2}$ inches in diameter. The intensity of the shadows from this and from the mechanical lamp were equal at a distance of 13 feet 3 inches, and 4 feet 6 inches respectively; taking the squares of these the Fresnel lamp gives about nine times the light of the mechanical, which latter may be assumed as equal to that of eleven average wax candles. On comparing one of the best Argand lamps with the mechanical, the former was to the latter as 10 to 11; so that the illumination of the Fresnel lamp, instead of being as has been asserted equal to 40 Argand lamps, is not equal to more than 9·6 of those lamps. In the Bude light a small stream of oxygen is sent up through a small tube within the burning wick, which is $\frac{5}{8}$ths of an inch in diameter, and the flame about $\frac{3}{8}$ths of an inch. The illuminating power is equal to about 30 wax candles. Dr. Ure also examined the illuminating power of different kinds of wax candles, and found that the light from a long-three and a short-three was the same, or $\frac{1}{11}$th of the mechanical lamp; also the light emitted from one of the six-to-the-pound was very little less, being $\frac{1}{12}$th of that of the mechanical lamp. The consumption of wax in a long or short-three may be taken at 126 grains per hour, and in a short-six at 125 grains per hour.

Wax contains 81·75 parts of carbon in every 100 parts, and the combustion of these 100 parts produces 36 parts of carbonic acid; consequently, a wax candle will generate per hour about 375 grains of carbonic acid, or 800 cubic inches of gas. Now an average sized man developes and exhales from his lungs 1632 cubic inches of gas per hour; thus the combustion of two ordinary wax lights deteriorates the air to about the same extent as the breathing of one man.

Fluidity of Liquids.

Dr. Ure detailed some experiments to which he had been led for determining the fluidity of different liquids by ascertaining the time in which a given quantity of liquid would run off through a syphon. The results were very curious: the syphon was $\frac{1}{8}$th of an inch in diameter, and the times which were occupied in running off by equal measures of naptha and alcohol, each weighing about 200 grains, were 80 and 120 seconds respectively. The same measure of sperm oil at the ordinary temperature took 2700 seconds, but when heated to 265° F. it only took 300 seconds. Southern whale oil took the same times at the same temperatures.

June 18, 1839.

The PRESIDENT in the Chair.

"An Account of the New Stone Bridge, over the River Lea, at Stratford-le-Bow." By John Buldry Redman, Grad. Inst. C. E.

Bow Bridge.

The old bridge, of which a full account by Mr. Burges is published in the Transactions of the Antiquarian Society, was perhaps the most ancient arched stone bridge in England, having been erected by order of Maud, the queen of the first Henry (A.D. 1125). The construction of this bridge and the alterations which had been made in it from time to time, are fully described and illustrated. This bridge being found exceedingly inconvenient both for the traffic and the navigation, in 1818 Mr. Walker recommended a plan for a new stone bridge, for which an act was obtained in 1834, and the work commenced in April, 1835. The progress of this work is the subject of this communication. The temporary bridge, the construction of which is accurately detailed, being finished, the removal of the old bridge was proceeded with, the arches thereof being supported by proper centering. The arch stones being laid bare, the old roadway was discovered—the ruts of the wheels and the track of horses and cattle being distinctly visible; the ruts were worn in some places to within 3 or 4 inches of the intrados, and in others quite through.

The new bridge is of Aberdeen granite, and consists of a single elliptical arch, 64 feet span on the square line and 66 feet on the skew, with a curved sine of 13 feet 9½ inches, the faces of the abutments making an angle of 70° 45′ with the face of the arch. The width of the bridge is 40 feet within the parapets. The progress of the work, the construction of the temporary bridges and of the coffre dams, and the laying of the foundations, are described in great detail and illustrated by drawings. The first course of footings was bedded upon concrete of 12 inches in thickness, composed of eight measures of river gravel and sand to one of lime. The lime was brought hot to the work, and being ground was mixed dry with the sand and gravel. Water being then added, the whole was thrown in from the level of the strutting pieces of the coffre dam, a height of 10 or 12 feet. The first six courses were faced with puozzolana mortar, composed of one and a half measure of sand, one of puozzolana, and one of lime.

The author fully details the construction of the centering and the dimensions of the timbers, the formation of the arch and templates of the arch-stones. The centering was eased on the forty-first day after the arch was keyed, and struck on the forty-second day; the arch subsided one inch during the erection of the work, and half an inch after first easing the centering; two inches having been allowed for the whole subsidence. The arch being completed, the abutments and wing walls were brought up to their proper level, and the cornice and parapets added; the crown of the arch and top of the abutments were covered with concrete, 1 foot 6 inches thick, upon which the foot-paths of Aberdeen granite and the roadway of screened gravel are laid. The approaches are bounded by retaining walls, as shewn in the drawings. The bridge was opened on the 14th of February, 1839, three years and ten months from the commencement of the operations.

The communication is accompanied by seven sheets of drawings, having the old, new, and temporary bridges, and their various parts, in elevation, plan, and section, with all the dimensions, accurately laid down.

"A new plan of construction of Sliding Gates for the Entrance Locks of Docks, &c." By J. C. Singels, Engineer of the Waterstaat, Hollande, &c. &c.

Sliding Lock Gates.

The improvement suggested consists in substituting for the ordinary Lock Gates, Sliding Gates, traversing the ends of the lock on rails laid on sills, drawn across by chains and capstans. The author in proposing this mode of construction assumes, that when a lock exceeds 50 feet in width, ordinary gates must be abandoned and caissons used. The advantages offered by it are, diminishing the length of the lock by that of the ordinary opening gate, consequently the volume of water to fill the lock is lessened in the same degree, and reducing the number of the locks; for as a small elevation is essential to the strength of the ordinary gates, the sliding gates may on the contrary be made of almost any height without any fear of impairing their strength or solidity.

In the description of the Plans accompanying the paper, great stress is laid on the whole length of the lock, with the exception of that part across which the gate traverses, being constructed on an invert arch, thus giving greater solidity than where a flat floor only is used, either for the whole length, or for the wide space necessary for the ordinary gates to swing upon. It is acknowledged that more masonry is required in this mode of construction, but it is argued that the extra expense will be met by the saving in the length of the lock and in the quantity of the water used.

In constructing the Sliding Gate, the timbers of which are cross braced and strutted, and then covered with planking on both sides, the rule to be observed is, that the thickness of the gate is one-fourth of the width of the lock, so that the main bracing timbers are at an angle of 20°. These are crossed by other timbers, also diagonally braced, extending the vertical height of the gate, so as to give that combination best calculated to withstand the pressure of the water on either side. To obviate the difficulty of setting in motion so heavy a mass as the sliding gate, it is proposed to place within it some barrels filled with air, which by their buoyancy would relieve the rollers of some portion of the weight, and enable the gate to traverse more easily.

Mr. Palmer observed, that the author could hardly be acquainted with the modern practice in constructing locks in this country, as timber had for a long period been but little used in the lock chamber. His practice had been invariably to have an invert arch at a lower level than the lock chamber. He was now constructing at Port Talbot, in South Wales, a lock of 45 feet span, in which there was an invert arch built of stone, 3 feet thick, with lias lime, placed on a stratum of concrete, 2 feet thick, the concrete being composed of four parts of gravel and sand to one of lime; above this invert, the floor was filled in with 2 feet thick of brickwork, laid in Roman cement. Beneath the roller curbs, stones were placed to bed them upon. Each lock gate weighed about 40 tons, one half of which was borne by the heel-post and the other half on the rollers, yet there was no difficulty in moving it at pleasure. The depth of the water was 30 feet, and sometimes the whole column pressed on the gates, yet no injury was feared. There had been great difficulty with the water during the course of construction, but the invert and the side walls placed on it were perfectly sound, and able to withstand any pressure. He apprehended that the sliding gate would be much heavier than the common gate—that the expense of construction would be greater—and he could not discern any compensating benefit to result from its adoption.

June 25, 1839.

JOHN MACNEILL, Esq. in the Chair.

The following were balloted for and elected: J. F. Hanson, John Llewellin, and W. Llewellin, as Associates.

The following communications were read in part:—

"On Steam Engines, particularly with reference to their consumption of Steam." By Josiah Parkes, M. Inst. C. E.

"On the Analysis of a portion of the Iron Heel-plate of the Stern-post of the John Bull, Steam Vessel." By David Mushet, A. Inst. C. E.

The action of the sea water had converted the iron into a substance somewhat resembling plumbago. Mr. Mushet, after analysing it, considers this substance, which had been called marine plumbago, to be composed nearly as follows:

Carbonic acid and moisture . .	20
Protoxyde of iron	35·7
Silt or earthy matter . . .	3·2
Carbon	41·1
	100

"On a method of Dowelling Timber by Iron Dowels and Asphalte." By M. J. Brunel, M. Inst. C. E.

"On the Expansion of Iron and Stone in structures, as shewn by observations on the Southwark and Staines Bridges." By George Rennie, F.R.S. &c. &c.

"A theoretical calculation of the amount of Fuel saved by working Steam expansively." By J. W. Lubbock, Hon. M. Inst. C. E.

The following communications were announced as received:—

"Observations on the efficiency or gross power of Steam exerted on the piston, in relation to the reported duty of Steam Engines in Cornwall at different periods." By John Scott Enys, A. Inst. C. E.

"Specifications and Drawings of the Gas Works at Middlesbro'-on-Tees." By Peter Henderson, A. Inst. C. E.

"On the construction of the Cherbourg Breakwater; with a Drawing." By G. S. Dalrymple.

"Drawing and Description of the Coffre Dam at the new Houses of Parliament." By G. S. Dalrymple.

TELFORD PREMIUMS.

The following Premiums were announced as awarded during the present session:—

Telford Premiums.

A Telford Medal in silver and 20 guineas to John Edward Jones, for his Description, Plan, and Drawings of the Sewage of Westminster.

A Telford Medal in silver to Charles Hood, for his paper on Warming and Ventilating Buildings.

A Telford Medal in silver to Charles Wye Williams, for his paper on the Properties and Application of Turf and Turf Coke.

A Telford Medal in silver to Edward Woods, for his paper on the Forms of Locomotive Engines.

A Telford Medal in bronze and books suitably bound and inscribed, of the value of three guineas, to Frederick Pollock, Lieut. Madras Engineers, for his Description and Drawings of the Coffre Dam at Westminster Bridge.

A Telford Medal in bronze and books suitably bound and inscribed, of the value of three guineas, to R. W. Mylne, for his communication on the Well sunk by the New River Company, at their Reservoir in the Hampstead Road.

A Telford Medal in bronze and books suitably bound and inscribed, of the value of three guineas, to John Buldry Redman, for his Description and Drawings of Bow Bridge.

The Council seized this opportunity of calling attention to the importance of making the Institution the depository of detailed

Drawings, Descriptions, and Models of works and machinery actually executed; also of professional Books, Papers, and Reports, which are of little value to the individual, but which, when collected and arranged in one place, would be of inestimable value to the Profession. They trusted that all who had such records at their disposal would consider the great service which might thus be rendered to the cause of the advancement of professional knowledge.

The following were announced as subjects for which the Council of the Institution of Civil Engineers would award Telford Premiums.

1. The Nature and Properties of Steam, especially with reference to the quantity of Water in a given bulk of Steam in free communication with water at different temperatures.
2. An Account and Drawings of the original construction and present state of the Plymouth Breakwater.
3. The ratio, from actual experiment, of the Velocity, Load, and Power, of Locomotive Engines on Railways.
    1st. Upon Levels.
    2nd. Upon Inclined Planes.
4. Drawings and Description of the Outfall of the King's Scholar's Pond Sewer, and of other Principal Outfalls of the Westminster Sewage; also, the inclination, dimensions, and forms, of the Sewers, and the observed velocities of water in them.
5. Drawings and Descriptions of the Sewage under the Commission for Regent Street, especially of the Outfall at Scotland Yard.
6. Drawings and Description of the best Machine for describing the profile of a Road, and also for measuring the traction of different roads.
7. The alterations and improvements in Blackfriars Bridge.
8. The explosion of Steam Boilers—Especially a record of facts connected with any explosions which have taken place: also, a description, drawings, and details, of the Boiler, both before and after the explosion.
9. Drawings, Sections, and Descriptions, of Iron Steam Vessels.
10. The comparative advantages of Iron and Wood as employed in the construction of Steam Vessels.
11. The advantages and disadvantages of the Hot and Cold

Blast in the manufacture of Iron, with statements of the quality and quantity of materials employed, and produce thereof.

12. The causes of and means of preventing the changes in texture and composition which Cast Iron occasionally undergoes when in continued contact with Sea Water.
13. The Properties and Chemical Constitution of the various kinds of Coal.
14. A Memoir of Sir Hugh Middleton, with an Account of his Works.
15. A Memoir of Arthur Woolf, with an Account of his Works.
16. An Account of the various methods lately employed for preserving Timber from Dry Rot and other sources of decay.
17. On the best Gauge for the width of Railways, with the result of the experience furnished by existing Railways.

The Communications must be forwarded to the House of the Institution, No. 25, Great George Street, Westminster, on or before the 31st of March, 1840.

It is not the wish of the Council to confine the TELFORD Premiums to communications on the above subjects; other communications of distinguished merit and peculiarly deserving some mark of distinction will be rewarded.

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INSTITUTION

OF

CIVIL ENGINEERS.

MINUTES OF PROCEEDINGS,

SESSION 1840.

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ADVERTISEMENT.

THE Institution is not, as a body, responsible for the facts and opinions advanced in the following abstracts of the papers read, and of the conversations which took place at the Meetings of the last Session.

INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1840.

ANNUAL REPORT.

Annual Report.

THE Council of the Institution of Civil Engineers, on resigning the trust confided to them by the last Annual General Meeting, solicit the attention of this Meeting, and of all those who are interested in the welfare of the Institution, to the following Report on the Proceedings and on the state and prospects of the Institution at the close of this the twenty-first year of its existence. At the last Annual General Meeting the Council of the preceding year had the gratification of congratulating the Institution on its then assembling in its new premises under circumstances which furnished so advantageous a contrast with the condition of earlier years, and such convincing evidence of the steady progress and success which had attended the labours of the Council and the co-operation of the general body. And though the year which is now closing upon you may not have been marked by events of so striking a character as the preceding one, the Council nevertheless experience the highest degree of satisfaction in reviewing the proceedings of the Session of the year so auspiciously commenced. Aware of the more extensive duties and increased responsibility entailed upon them, the Council have endeavoured so to direct the affairs of the Institution as to keep pace with its growing importance; and they can with confidence assert, that the proceedings of the last Session have not been inferior in interest or importance to those of any preceding Session; whilst the attendance at the meetings and the anxiety which is evinced by strangers to become acquainted with the proceedings and objects of the Institution, shew the estimation in which it is held both at home and abroad, and fully warrant the most sanguine anticipations of its future and continually increasing success.

Bye Laws. The attention of the last Annual Meeting was directed to the expediency of some alteration in the existing laws, particularly with reference to the election of Officers and the number of the Council. It was suggested that the annual election of the Council should be conducted in a somewhat different manner from that hitherto pursued; that a greater number than that constituting the Council should be nominated, and that, consequently, each person at the Annual General Meeting, instead of, according to the then existing practice, erasing one name and substituting another, should erase as many names as the number on the Balloting List exceeded the constituted number of the Council. It was also suggested, that it would be for the advantage of the Institution that the Council should be increased by the addition of two Members: That as some Members of the Council are frequently prevented by professional engagements from regular attendance, the Council should be enlarged to as great an extent as might be consistent with the true interests of the Institution. These and some other suggestions for the better regulation and stability of the Institution were subsequently submitted to a General Meeting of Members, and now constitute part of the Bye-Laws of the Institution.

Transactions. The practice of other societies in publishing their Transactions in parts, containing such communications as were ready at frequent and short intervals, was briefly touched upon in the last Report, and was discussed in considerable detail at the last Annual Meeting. Such is the nature of some communications, that delay in their publication may be considered not only as a positive injustice to the author, but as detrimental to the cause of practical science and the best interests of the Institution; and if the publication of such papers be delayed until a whole volume is ready, authors will inevitably avail themselves of other channels for bringing their labours before the world. Add to which, when a whole volume containing many valuable plates is to be published, the sources of delay are numerous, and such as cannot be avoided. The Council conceive that the experience of the past year has fully borne out the preceding views, and shewn the great importance and value of prompt publication. Early in the Session the Institution received a most valuable communication from your member, Mr. Parkes. It was considered desirable that the publication of this communication, forming as it did a continuation of his researches already published in the second volume of the Transactions, should not be delayed. No other communications being then ready for publication, the Council resolved to publish it at once as the first part of the third volume. This has now been for some time in the hands of the public, and the number of copies which have been disposed of shews the great desire evinced to obtain these papers so soon as published. The Council have also had still further proof of the importance of this plan. The Institution received during the last Session several communications well suited for publication in the Transactions, and among them the continuation and conclusion of that already mentioned by Mr. Parkes. Preparations were made for the immediate publication of these papers in a second part; difficulties and delays which could not have been foreseen or prevented occurred in the publication of some of them, and thus the second part contains but two instead of the nine communications originally destined for it. The greater portion of the remaining seven papers are already printed and the plates engraved, so that the third part will be in the hands of the Institution in a very short time. There are several other valuable communications in the possession of the Institution now in the course of preparation for publication, and which will appear so soon as circumstances will permit.

Minutes of Proceedings.

The Minutes of Proceedings have been printed at such short intervals during the Session as the abstracts of Papers and Minutes of Conversation would furnish sufficient materials. The Council conceive that great advantages may, and indeed have resulted from a publication of this nature. An authentic account of the communications is thus immediately furnished, attention is continually kept alive to the subjects which are brought before the Institution, and the statements there recorded have elicited very valuable communications, which otherwise would probably never have been called forth. No one can turn over the Minutes of the last Session without remarking the number and the diversity of the facts and opinions there recorded, very many of which were elicited by the statements contained in some written communication, or casually advanced in the course of discussion.

Discussions.

The Council cannot omit this opportunity of insisting on the importance of these discussions in promoting the objects which the Institution has in view. The recording and subsequent publication of these discussions are features peculiar to this Institution, and from which the greatest benefits have resulted and may be expected, so long as the communication of knowledge is solely and steadily kept in view. It would be easy to select many instances during the last and preceding Sessions, of some of the most valuable communications to the Institution owing their origin entirely to this source. The first communication from Mr. Parkes arose entirely out of the conversations which took place on the superior evaporation of the Cornish Boilers being referred to as one cause of the great amount of the duty done by the Cornish Engines. The communication by Mr. Williams on Peat and Resin Fuel owes its origin to his being accidentally present at the discussion on the uses of turf in the manufacture of iron: whilst that by Mr. Apsley Pellatt, on the relative heating powers of Coke and Coal in melting glass, arose entirely from the discussion of the facts stated by Mr. Parkes respecting the superior evaporation produced by the coke from a given quantity of coal than by the coal itself. And lastly, the extremely interesting and highly valuable discussions at the commencement of last Session on the uses and applications of turf; and on the extraordinary coincidence between the results obtained by Mr. Lowe, Mr. Parkes, Mr. Apsley Pellatt, and Marcus Bull, of Philadelphia, experimenting as they did with totally different views, and under totally different circumstances, must be fresh in the recollection of all present.

But, besides the positive advantages which have thus resulted, and may be expected, from a steady adherence to these practices so peculiar to this Institution, there are others of the greatest value to those engaged in practical science. By this freedom of discussion, statements and opinions are canvassed, and corrected or confirmed, as soon as promulgated—the labours of authors and claims of individuals are made known and secured as matter of history—and attention is continually kept alive to the state and progress of knowledge in those departments of science which it is the especial object of this Institution to promote. The Council trust, therefore, that those individuals who have stored up knowledge and facts for many years past, and devoted themselves to some particular branch of science, will consider how much they have in their power to contribute, and how great is the assistance which they can render to the labourers in other branches, and, above all, to those who are ambitious of following in their steps, by freely communicating, either orally or in writing, the knowledge which they have collected; so that the records of the Institution may be unparalleled for the extent and correctness of the information which they contain.

Telford Premiums.

The Council have endeavoured from time to time to direct attention to subjects on which it was conceived communications were needed or desirable, by proposing such subjects as objects for the Premiums, placed at the disposal of the Council by the munificence of the late President. The communications sent in compliance with this invitation have not been numerous. Two, however,—one by your associate Mr. Jones, on the Westminster Sewage, and the other by Mr. Hood, on Warming and Ventilating,—seemed to call for some special mark of distinction.

The communication by Mr. Jones is of the most elaborate and costly description. It consists of a large Plan of the City of Westminster, drawn to a scale of one inch to 200 feet, compiled from the originals in the possession of the Commissioners of Sewers of that district. Upon this are laid down the boundaries of the city, and parishes, and all the principal streets and squares, with the main and collateral lines of sewers, differently coloured, so as to be readily distinguished. This, with the Book of Sections, consisting of upwards of 100 sheets of tables and drawings of details of levels, lengths, and construction, furnishes an exact and authentic record of a work of great magnitude. Any extended remarks on the benefits conferred on our metropolis by the system of underground drainage, would be here superfluous. Works of this nature are of the highest public importance, and have been repeatedly the subject of legislation by both general and local acts. The Council conceived that, in awarding to Mr. Jones a Telford Medal in Silver and Twenty Guineas for this laborious communication, they were bestowing a suitable mark of approbation on the Author of a record which is nearly unparalleled, and must be of great value as a source of information in all future works of this nature, when other, and particularly foreign, cities carry into effect a system of drainage, in which they are at present so deficient. Mr. Jones.

The Council cannot pass from this subject without expressing the obligations which the Institution is under to the Chairman and the Commissioners of the Sewers of the Westminster District. On its being intimated to them that the Council wished some account and record of the work over which they preside, permission was immediately given for any person desirous of preparing such account to have free access to all the documents in their possession relating to this subject, and to make such extracts or copies therefrom as could in any way contribute towards this object.

The communication by Mr. Hood contains a detailed account of the principles on which the salubrity of the atmosphere in crowded rooms depends, and the various methods which have been adopted for warming and ventilation. The Author has briefly touched on the various modes of warming generally adopted, and points out the great difficulty which exists of preserving those conditions of the atmosphere which are essential to healthy respiration wherever close stoves or surfaces which may become too highly heated are employed. The importance of ventilation, and the success which has attended the adoption of mechanical means in the manufacturing districts, are subjects worthy the attention of all who study the Mr. Hood.

health of those who, from choice or necessity, are exposed to the generally unwholesome atmosphere of crowded apartments. This subject is of the highest importance to the manufacturing poor of this country, who are compelled to work in crowded rooms at high temperatures. The Council are aware that much has been done towards this object in some of the large cotton works of Great Britain, and they hope ere long to obtain some detailed account of the means by which this has been accomplished, and the results which have ensued.

The Council have also awarded a Telford Medal in Silver to your Associate, Charles Wye Williams, for his communication on the Properties, Uses, and Manufacture of Turf Coke and Peat Resin Fuel; and to Mr. Edward Woods, for his communication on Locomotive Engines.

Mr. Williams.

The various applications of Peat as a fuel had been repeatedly the subject of discussion at the Meetings of the Institution, and this communication may (as has been already noticed) be attributed to the discussions then going on. It is well known, that the attention of Mr. Williams, as manager of the City of Dublin Steam Packet Company, and otherwise intimately connected with steam navigation in Ireland, has been for many years directed to the application of Peat or Turf as a fuel. Public attention was more than thirty years ago directed to this subject by Mr. Griffiths, who designated the bogs of Ireland as "mines above ground." The scarcity and cost of coal, as contrasted with the abundant supply and cheapness of peat, had long since led to the use of the latter in the steamers on the Shannon. Its bulk and tendency to absorb moisture are, however, serious impediments to its use; but these may be successfully combated by care in the preparation. Moreover, the peat, properly selected and prepared, being a carbon of great purity, is superior to every other substance for all purposes of metallurgy. But, in these researches, Mr. Williams had ulterior objects in view. He sought, by the preparation of an artificial fuel, to form a combination which should closely resemble the best kinds of natural coal, by combining with turf coke, resin, or some other bitumen of great purity, so as to produce a compound in which great heating power should exist in small bulk, and thus avoid the excess of bitumen and deficiency of carbon in the Cannel coal, as well as the deficiency of bitumen and excess of carbon in the Anthracite. It would be foreign to the object of this Report to dwell on the preparation of this fuel, or the purposes to which it is applicable; it will suffice to refer to the numerous discussions on this subject recorded in the Minutes of last Session, and to the Paper now published in the Second Part of the Third Volume of your Transactions.

Mr. Woods

The communication by Mr. Edward Woods, published in the Second Volume of the Transactions, will always bear a prominent place among the records of practical science, as one of the earliest and most accurate details on the actual working of Locomotive Engines. The first communication was received early in the Session of 1838. The Author was thought capable of adding so much to his already valuable communication, that the Council referred it back to him for this purpose, and it was not received in the form in which it appears in your Transactions till after the premiums for that Session were awarded. But this communication (notwithstanding the interval since it was laid before the Meeting) will probably be fresh in the recollection of most present, from its giving an accurate account of the progress of the Locomotive Engines on the Liverpool and Manchester Railway from the opening of that important work. The experience of Engineers had at that time furnished them with but little knowledge as to what were the most essential requisites in Railway Engines, and the advance of knowledge, as shewn by the history of the Locomotive Engine on this railway, is a most interesting and instructive lesson to every one who would study the progress of practical science and improvement. Great alterations were found necessary in the strength of the parts, in the weight of the engines, in the road, and the number of wheels. The first engines were gradually adapted to the necessities of the case, and the arrangements then resorted to as necessary expedients have now been adopted into the regular and uniform practice. Besides the extreme interest of that which may be termed the history of these improvements, the communication is replete with theoretical principles as to the working of Locomotives, and the advantages and disadvantages incident to peculiar practical adaptations. It would exceed the limits of this Report to do more on the present occasion than briefly to state that this paper contains extended remarks on the relative advantages of four or six wheels, of inside or outside framings, of crank axles or outside crank pins, of coupled or uncoupled engines. The Council would point out this paper to the junior members of the profession, as an example of how great a service may be rendered by simply recording what passes under their daily observation and experience.

The Council have also adjudged a Telford Medal in Bronze and Books to the value of Three Guineas to Mr. R. W. Mylne, for his communication on the Well sunk at the reservoir of the New River

Company at the Hampstead Road; to Lieutenant Pollock, for his drawings and description of the Coffre Dam at Westminster Bridge; and to Mr. Redman, for his drawings and account of Bow Bridge.

Mr. Mylne. The communication by Mr. Mylne contains an account of the various attempts which have been made in the metropolis and its environs to obtain water from the sand strata, by means of wells and small bores, in which the water rises naturally to the surface. These attempts, and the raising the water by artificial means from the sand strata, have been for the most part unsuccessful. In some cases, parties having communications with the same sand stratum and contiguous to each other, were unable to obtain water at the same time, as the drawing water by one had the effect of destroying the supply of all the others. In other cases, the sand coming away with the water, large cavities were formed of such a nature as, after a short time, entirely to suspend the progress of the works. Of the latter difficulty, some remarkable instances occurred during the sinking of the well in the Hampstead Road, which are particularly described in the communication. The supply of water from the sand being, from the causes just alluded to, very precarious, the New River Company, in March, 1835, determined on sinking a well through the clay and sand into the chalk, for the purpose of ascertaining the supply of water from this source. The peculiar difficulties experienced in the progress of this work, and the means by which these and similar difficulties are to be overcome, as set forth in the report of Mr. Simpson, appended to the communication, furnish a valuable compendium of information on this subject; and, being replete with practical details of an executed work of no ordinary difficulty, is one of those communications to which the Council are most anxious to give every encouragement in their power.

Mr. Pollock and Mr. Redman. The communication by Lieutenant Pollock on the Coffre Dam now fixed round the 13 and 14-feet piers of Westminster Bridge, and by Mr. Redman on the New Stone Bridge over the River Lea at Stratford-le-Bow, are of a similar character with the preceding; they are both accurate accounts, accompanied by valuable drawings, of important works actually executed. The collection of such records ought ever to be a primary object with the Institution, and their authors are most justly deserving of such marks of distinction as it is in the power of the Institution to bestow. The Council would point out the above as instances of the facility with which individuals may contribute to their own advancement and reputation. no less than to the objects which the Institution has in view;

and would more particularly advert to Lieutenant Pollock, who, while in England, on leave of absence from India, occupied himself in acquiring engineering knowledge, and, with most praiseworthy diligence, availed himself of the opportunities afforded him of observing and recording the progress of the works at Westminster Bridge. Works of this nature are accessible to most of those who are studying for the profession, and by making use of the opportunities which are afforded them, they will be able to prepare communications most deserving of such distinctions as those which have just been conferred.

Mr. Parkes.

Among the other communications of the Session, the Council cannot, on the present occasion, omit to notice those of your Member, Mr. Parkes. His communication on the Evaporation of Water from Steam Boilers, for which a Telford Medal in Silver was awarded during the preceding Session, and the interesting discussions to which it gave rise, are too well known to require further comment. But, great as were the benefits conferred on practical science by the facts there recorded, they have been much surpassed by the subsequent labours of this author. In continuation of his subject, you received early in the Session the first part of a communication on Steam Boilers; and at the close of the Session, the second part, treating of Steam Engines. Before Mr. Parkes was induced to turn his attention to the preparation of these communications, no attempt had been made to bring together, in one connected view, the various facts which had been ascertained. The economy of the Cornish system was indisputable; but to what it was to be referred was involved in some obscurity. It was reserved for this communication to call attention to certain quantities and relations which exerted a peculiar influence over the results; and which, being rightly ascertained, were at once indicative or exponential of the character of the boiler. If it be found that, in one class of boiler, the same quantity of coal is burnt eight times as rapidly as in another class—that the quantity consumed on each square foot of one grate is twenty-seven times that on the grate of another—that the quantity of water evaporated bears some definite relation to the quantity of heated surface—and that there is twelve times more evaporated by each foot of heated surface in one class of boiler than in another—and finally, that the quantity of water evaporated by a given weight of fuel is in one class double the quantity evaporated in another,—we have arrived at some definite relations whereby to compare boilers of different kinds with each other. To these definite quantities and relations, the author, with apparent propriety, assigns the term "exponents;" and these being compared together for different boilers, their respective merits as evaporative vessels are readily perceived. Mr. Parkes has also called the attention of engineers to the effect of the element time, that is, the period of the detention of the heat about the boiler. The importance of attending to this cannot be too strongly insisted on; as it would appear from these statements, that boilers being compared with each other, in respect of their evaporative economy, are nearly inversely as the rate of combustion. Attention is also called to the fact, that there are actions tending to the destruction of the boiler entirely independent of the temperature of the fire, and which may be designated by the term "intensity of calorific action." Of their nature we know nothing, but the durability of different boilers, under different systems of practice, affords some means of comparing the intensity of these actions.

Mr. Parkes having, in the first part of the subject, thus pointed out the distinctive features of the different classes of boilers as evaporative vessels, proceeds, in his subsequent and concluding communication, to consider the distribution and practical application of the steam in different classes of steam engines. And for this purpose, he is led to consider the best practical measure of the dynamic efficiency of steam—the methods employed to determine the power of engines—the measures of effect—the expenditure of power—the proportion of boilers to engines—the standard measure of duty—the constituent heat of steam—the locomotive engine—the blast and resistance occasioned by it—the momentum of the engine and train, as exhibiting the whole mechanical effort exerted by the steam—the relative expenditure of power for a given effect by fixed and locomotive non-condensing engines. This bare enumeration of the principal matters in the second communication will give some, though a very inadequate, idea of the magnitude of the task undertaken by Mr. Parkes, for the communication is accompanied by elaborate and extensive tables, exhibiting the results of the facts which he has collected and used in the course of his inquiry, and it may confidently be asserted that a more laborious task has rarely been undertaken or accomplished by any one individual than the series of communications thus brought before the Institution.

It will be one of the earliest duties of the succeeding Council, to consider in what manner the sense of the great benefits conferred on this department of practical science can most appropriately be testified.

Mr. Leslie. The Council also received, at the close of last Session, from your Member, Mr. Leslie, a most valuable communication on the Docks and Harbour of Dundee. This is one of the records on which the

Institution sets the highest value, being the detailed account of an executed work of great extent. It is not, in its present form, well adapted for being laid before the Meetings; but on its publication, which will take place very shortly, the Institution will have an opportunity of judging of the high value which it possesses.

Presents. In acknowledging, with gratitude, the numerous and valuable Presents made to the Institution during the past year, the Council would call the attention of the Members generally to the want still existing in the Library of works of reference on general Books. scientific subjects not immediately connected with engineering, and express a hope that such wants may be supplied by that liberality to which the Institution is already so deeply indebted. The Collection of Models also requires many additions to render it as Models. complete as the Council could wish, and it is only by the wants of the Institution being constantly borne in mind by all who are interested in the subject, that such a collection can be formed as shall be worthy of the Society.

Several societies have made an exchange of Transactions with the Institution, and from the Royal Society of Edinburgh, the Philosophical Society of Manchester, the Royal Irish Society, and the Royal Astronomical Society, sets of Transactions, as complete as could be made up, have been received. The Master-General of the Maps. Ordnance, the Lord-Lieutenant of Ireland, and Colonel Colby, continue their liberal presents of the English and Irish Surveys; and Charts. Captain Beaufort and the Secretary of the Admiralty have continued the present of the series of Admiralty Charts. The Institution is also Busts. indebted to Mr. Vignolles for the Busts of Locke and Dr. Hutton; to Mr. Field, V.P., for a Bust of the late Henry Maudslay; and to Mr. Rivers, for that of Dr. Faraday.

Library of Dr. Young. The Council would wish to take especial notice of the large collection of works of the late eminent philosopher, Dr. Young, now deposited in your Library. For this great acquisition, the Institution is indebted to the kindness and liberality of his brother, Mr. Robert Young, who conceiving most justly that every thing connected with so great a benefactor to practical science must be highly valued by this Institution, has made it the depository of these books from the library of his distinguished relative. The Council, in thus publicly recording their sense of the kindness and liberality of Mr. Robert Young, would earnestly press upon others the importance of following so noble an example, and of presenting such works as are at their disposal, and of which the Library of the Institution is particularly in need.

Telford Monument. It was announced through the medium of the last Annual Report, that the monument of Telford was nearly finished, and that a site had been selected in Westminster Abbey. The Council have now the satisfaction of announcing, that the monument is fixed in the place destined for it, and they are confident that all who enjoyed the acquaintance, or knew the merits, of the late distinguished President of this Institution, will rejoice that the memory of one so eminent and so highly deserving has met with so proper and just a tribute of respect; whilst all, no less than those by whose liberality the monument was erected, will feel that he has a name which will endure so long as there exists a record of the triumphs of the British Engineer.

Mr. Davies Gilbert.

It would be vain to expect that an Annual Meeting should ever recur without the Council having to lament the removal by death of some who, by their acquirements, or by their associations of friendship, were endeared to the Institution. On the present occasion the Council have to lament the death of your Members, Mr. David Logan and Mr. Henry Habberley Price, and of your Honorary Member, Mr. Davies Gilbert. The records of the Institution contain several communications from Mr. Logan, particularly one on the new Graving Dock at Dundee, and Mr. H. H. Price was, when in town, a constant attendant at the Meetings, and took a lively interest in the proceedings and success of the Institution. Mr. Davies Gilbert was, by his writings and his influence, a great benefactor of practical science, and the Transactions of the Royal Society, over which he presided for three years, contain several papers of great value to the practical engineer. He took great interest in the introduction of Mr. Watt's improvements in the steam engine into the Cornish mines, and in the controversy betwixt Mr. Watt and Mr. Jonathan Hornblower respecting working steam expansively, the former employing one cylinder only, the latter two cylinders, in the manner afterwards revived by Woolf; the theoretical efficiency of the two methods being identical, but simplicity and mechanical advantage being greatly in favour of the former, as its present universal adoption testifies. Mr. Davies Gilbert introduced into practical mechanics the term "efficiency" as the product of the applied force and of the space through which it acted in contradistinction to the term "duty," as indicative of a similar function of the work performed. His attention was also directed to the theory of suspension bridges, when the plan for making such communication across the Menai was submitted to the Commissioners appointed by Parliament. It appeared to him that the proposed depth of curvature of the catenary was not sufficient, and his well-known theoretical investigation of this subject was undertaken with the view of ascertaining this fact; and in consequence of these investigations, the interval between the points of support of the chains and the roadway was increased to the height which appeared to him requisite for works of this nature. The labours of this distinguished individual for the promotion of science were unremitting. He was the founder of several societies; he was the discoverer and early patron of the talents of Davy; and while in parliament he laboured most assiduously in the advancement of all the public works. Regret for such a man, exerting the power of his mind so advantageously and through so many years, must always be strong and sincere; but having attained the ordinary limit of human life, he sunk into the grave amidst the respect and esteem of all who knew him, and has left behind him a name which will ever bear a prominent place amidst the names of those whose lives and talents have been devoted to great and noble purposes.

Cash Account.

In presenting the following statement of the Receipts and Expenditure of the Funds of the Institution for the year ending the 31st of December, 1839, the Council remark, with pleasure, that the state of the finances may be considered flourishing; but, at the same time, there still remains a debt of about £750. incurred for the alterations and improvements to the premises occupied by the Institution, and towards the liquidation of this they would solicit the assistance of those Members who have not yet contributed to the amount already subscribed.

Dr.			
To Balance in hands of Treasurers	305	18	10
— Subscriptions and Fees	1054	18	10
— Dividends	68	8	10
— House Subscriptions	355	16	0
	£1785	2	6

Cr.			
By House			
— No. 1, Cannon Row, for Rent, Taxes and Repairs...........	81	11	9
— No. 25, Great George Street, on account of Repairs, &c.	627	0	0
— Ditto, Rent, Taxes, and Insurance	117	3	3
— Lease of Ditto	8	2	0
— Salaries & Commission	347	15	11
— Servants' Wages	95	0	0
— Postage and Parcels..	18	5	5
— Stationery & Engraving	0	17	0
— Coals, Oil, &c.......	41	0	6
— Tea and Coffee......	31	4	3
— Printing............	40	10	6
— Library	37	13	10
— Publications.........	33	15	0
— Furniture	53	12	9
— Telford Premiums....	89	8	0
— Ironmongery, Household Utensils, occasional Assistance, Petty Cash Disbursements, and Sundries	45	10	6
— Balance............	116	11	10
	£1785	2	6

It must be noticed that the amount possessed by the Institution in the 3 per cent. Consols remains untouched; that the House in Cannon Row is let at the advanced rent of £100. per annum, and that some advantage has been derived from the temporary occupancy of the ground-floor of this house by the Railway Society. That Society has now relinquished these rooms, and it is proposed to retain and use them for the convenience and accommodation of the general body.

Conclusion.

The Council now resign into the hands of the Annual General Meeting the trust which was confided to them. The review of the proceedings of the past year has been to them in the highest degree gratifying, and they trust that every one here present will have participated in that gratification. The Institution has received the accession of many valuable names during the past year, and many others will, it is hoped, be added in the year which is now commencing. But they would remind all, that it is only by individual exertions that great ends can be accomplished. They would earnestly call on all to co-operate with the future Council in the promotion of professional knowledge, and in placing the Institution in a position conspicuous amongst those which have adorned this or any other country.

ADDRESS OF THE PRESIDENT

TO THE

GENERAL MEETING,

FEB. 4, 1840.

This being our first Meeting since my re-election as your President, allow me to thank you for the honour conferred upon me, and to congratulate you on the choice you have made of the other Members of Council, and Officers, who will I am sure be desirous of justifying the good opinion you have formed of them, by as frequent an attendance at the Meetings and attention to the business of the Institution, as their avocations will permit. This will indeed be but a proper return for the proof of your confidence in us, and I trust that the list of attendances, if again called for at the end of the season, will prove my anticipations to have been correct; for notwithstanding the truth of the old saying, that "where there is a will, there is a way," it must sometimes happen, that the attendance of some of us becomes impossible, from absence at too great distance or other cogent cause; yet I hope I may answer for my colleagues as for myself, that it is our determination to shew that we have the "*will.*" But, gentlemen, be it remembered on your part also, that there is a reciprocal duty to perform—that of attendance at our Meetings, to give them the importance which the Council Table being full will not give, if the seats around the room are not respectably occupied; and that blame may not attach where praise is due, the Council (following the precedent set them) have desired a list to be made and tabulated of the attendance at the Meetings, of each Member, Graduate, and Associate.

I trust, however, that there will be presented to your attention during the session so much new and interesting matter as will rather ensure your attendance as a personal gratification than as a bare discharge of a duty; unless this should be the case, mine would be an ungracious task to require your constant attendance, but if we succeed in exciting your attention, you will then come unasked. This good can only be attained by numerous and useful communications, which are valuable in themselves and give rise to instructive discussions. The Council therefore require plans and papers from you with the view of ensuring your personal attendance; and I wish to enforce this especially upon the country Members, from whom we receive very few communications. Looking at the extent and rapid progression of public works in this country at present, the new facts that are constantly being developed, and the number and influence of the Members of our Institution, there ought not to be any dearth of important and interesting communications. That we have had many such, and that the number of them is increasing, I admit, but still they ought to be much more numerous. My remarks at the last Meeting referred more particularly to Graduates and Associates as defaulters on this head, but I must include the *Members*, not only for what they could themselves do, but more for the exercise of the influence they possess over Graduates in directing their attention to particular objects or works on which they might furnish communications. Half the work is done "when the subject is *fixed* on:"—I say this from experience, as would be proved by reference to the communications that have been made through my suggestions at works which I have visited, or by individuals over whom I may be supposed to have some influence. If gentlemen would bear in mind the wants of the Institution whenever they visit any public work, they would rarely leave it without having reaped some knowledge that would be worth communicating, and they may be assured that their labours would be duly appreciated.

I named at the last Meeting the subject of the Library—I stated that which many gentlemen were not aware of, the understanding amongst ourselves, that each Member of the Council should contribute annually some Book, Picture, Drawing, or other present for the Library—I stated also that the Secretary was preparing a list of such books as it is desirable we should possess. This list will be printed and circulated, and I wish the Institution to understand that the Council do not desire to monopolize the right of presenting books, but trust that their example will be followed by every one belonging to the Institution. We have space now for a good Library, and for an Institution like ours nothing can be of greater importance. It is especially necessary that our Library should contain as many good books of reference as possible, and I beg to suggest to Members possessing such books, that in presenting them to the Institution they do not deprive themselves of the advantage of them, but will have the satisfaction of permitting others to participate with them.

The increasing business of the Institution appearing to the Council to require now the whole and undivided time and attention of one properly qualified gentleman as Secretary, they thought it their duty to make this a condition previous to appointment; I am glad to say Mr. Manby has accepted the office on these conditions. Mr. Webster, with whose abilities and science we are all well acquainted, has been elected Honorary Secretary, and the more of his time he can give us, the more, I am sure, we shall all feel obliged.

The question of qualification for Honorary Members has already engaged the attention of the new Council, and we may think it right shortly to bring the subject before the Institution. As the Bye Laws now stand, the necessary qualification for a candidate for election as an Honorary Member is, that "he be eminent for *science* and *experience* in pursuits connected with the profession of a Civil Engineer, but not engaged in the practice of that profession in Great Britain or Ireland." Now this distinction is so very circumscribed, that few men can be found who come strictly within its limits, whether we refer to the present list of Honorary Members, or even to the most distinguished individuals in this country who hold the highest places in science or scientific institutions, such as the President of the Royal Society, the Marquis of Northampton, the Chancellor of the University of London, Lord Burlington. (I cite these two noblemen, whose love of and devotion to science, and whose eminence in certain departments of it, have entitled them to the high places they fill, as persons whom it might be very desirable to connect with the Institution, should such be their wish, but neither of whom can, so far as I know, be strictly said to be "eminent for *science* and *experience* in pursuits connected with the profession of a Civil Engineer.") If it be thought desirable to extend the terms of qualification, the definition may be altered to include individuals distinguished for their patronage and promotion of the studies and works of Civil Engineering, or a class of Patrons might be formed of such men. The Council will give this matter their best consideration, and will, I am sure, in any recommendation they may make, be guided by their desire only to extend the reputation and importance of the Institution.

My old and valued friend, Mr. Turner, of Rook's Nest, Surrey (formerly the friend and partner of Huddart), having presented me with an excellent portrait of that eminent philosopher and mechanic, I have thought that I could not do better than offer it to the Institution, having previously had Mr. Turner's entire approval of my so doing. Those who have seen Huddart's Rope Machinery, which was I believe as much the creation of his own brain as ever machine was of any man's, will not dispute my claiming for him the first rank for eminence in Mechanics: as a Navigator and Hydrographer, he was inferior to none: I had the pleasure of knowing him, and have always thought, that if the Mechanical Philosophers and Engineers of our days were to be ranked in pairs, Huddart was the man to be placed by the side of Watt. I am glad therefore to be the instrument of putting the Institution in possession of the portrait of Huddart, by Wildman, after Hoppner; but this is not unmixed with a feeling of jealousy, arising from our Member Mr. Burges having discovered that Mr. Whitbread had, at his seat in Bedfordshire, a portrait of *Smeaton* (a soul-stirring name to Engineers), by Gainsborough; he has, through Mr. Whitbread's kindness and by the aid of Mr. Turner, placed the picture in the hands of Mr. Wildman, the talented painter of Huddart's portrait, and I can answer for Mr. Burges's kind intentions towards the Institution in the trouble he has so taken.

I have only farther to add, that the Council have come to the resolution of devoting the rooms on the ground floor to the use of the Members of the Institution, and have directed the periodical publications to be placed there. We hope this arrangement will be found generally convenient and agreeable, and we think it will be particularly so to our junior branches and Members from the country, as they may there enjoy all the advantages of a club, with the additional one of being surrounded by their friends.

We trust our Funds will always admit of this arrangement being gratuitous, as well as suffer us hereafter to add to it other means of attraction.

In another point of view it may be found useful, as a central point where gentlemen may make known their being at liberty to accept engagements, and the Engineer may find the assistance he is in need of.

ORIGINAL COMMUNICATIONS.

Ballard, S. Description of the Turn-bridges on the Hereford and Gloucester Canal. With a Drawing.

Barlow, P. An investigation into the power of Locomotive Engines, and the effect produced by that power at different velocities.

Borradaile, J. On the advantages of clothing Boilers with Felt.

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——— Continuation of ditto.

——— On Steam Engines, particularly with reference to their consumption of Steam.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1840.

Jan. 14.

JOSHUA FIELD, V. P., in the Chair.

"Observations on the efficiency or gross power of Steam exerted on the piston in relation to the reported duty of Steam Engines in Cornwall, at different periods." By John Scott Enys, Assoc. Inst. C. E.

Efficiency of Steam.

The advantages which may result from the union of scientific and practical knowledge in the application of steam power, particularly with reference to the limits of gross power, are great, as likely to check the extravagant notions entertained by some with respect to the farther increase of duty, and to remove the disbelief of others with respect to the amount of duty actually performed.

The limit of duty for atmospheric steam may be readily arrived at, as was done by Mr. Davies Gilbert in 1827, by estimating the weight of water which would rise 34 feet into a vacuum formed by the condensation of steam of atmospheric strength; whence it appears, that a higher duty than 30 millions cannot be obtained by atmospheric steam, 14 cubic feet of water being evaporated by a bushel of coal. Tredgold, in the first edition of his Treatise on the Steam Engine, published in 1827, adopted the simpler method of multiplying the volume of steam of atmospheric strength by the pressure, for the measure of the efficiency. This principle may be extended to measure the efficiency of steam at higher pressures, as the author has shewn in the first annual report of the Cornwall Polytechnic Society; and an extended table to ten atmospheres is appended to this communication.

The author then proceeds to shew, that the Cornish engines are worked under conditions such that a large proportion of the expansive action of the steam is available on the piston, and calls attention to two necessary corrections—1st, for the deficiency of water in high steam cut off at $\frac{1}{5}$th of the stroke; and 2d, for the increase of temperature of the steam during expansion in the cylinder, as derived from the steam jacket. The experiments of Mr. Wicksteed, confirmatory as they are of the very extended experiments made by Woolf at Wheal Alford, shew the importance of this latter correction. Some error has also arisen from the use of the boiler pressure. The exact determination of the pressure in the cylinder is difficult, and the only recorded experiments are those by Mr. Henwood with the common indicator, and published in the second volume of the Transactions of the Institution. The indicator is liable to shew a pressure higher than that actually exerted during the expansion, but it may be relied on for comparative results; and very accurate experiments made at the Consols by a mercury gauge, the engine being stopped at different parts of the stroke, are said to confirm the reliance which may be placed on the indicator.

The quantity of water evaporated was very imperfectly recorded; it was stated by Watt as from 8 to 12 cubic feet per bushel, and at present may be stated at about 14 cubic feet, but is sometimes, with good coal and careful stoking, much higher.

The author briefly alludes to the progress of improvement in Cornwall; the introduction by Woolf of high steam; the substitution of the plunger pole for the bucket pump, and the application, so recently made by Mr. James Sims, to stamping or crank engines of the arrangements which had been a long time so advantageously in use in pumping engines.

The communication is accompanied by a table, exhibiting the weight of water per cubic foot; the pressure; the volume and the efficiency of steam from one to ten atmospheres, adapted and corrected from those of Clement and Desormes. It is also accompanied by a method of representing several particulars connected with the load and engine; by which the relation of these with respect to each other in the same engine, and the different conditions of other engines, may be at once exhibited to the eye. It may also prove a convenient method of recording facts and calculations in connexion with the Indicator Diagrams.

"Analysis of a piece of the iron heel post converted by the action of Sea Water into a substance resembling Plumbago." By David Mushet, A. Inst. C. E.

Marine Plumbago.

A piece of the iron heel post of a vessel called the John Bull had been presented last Session by Mr. Borthwick, as a curious specimen of the effect of salt water in converting iron into a substance resembling plumbago. This substance was of a dark brown colour, and easily cut by a knife, and Mr. Mushet undertook to analyse it; and the result of this analysis, and the methods pursued, are the subject of this communication. This substance, which it may be convenient to call marine plumbago, on being exposed to a red heat in a crucible, lost about 20 per cent. in weight, and on being exposed to a white heat for four hours lost about 60 per cent., and came out a light mass of very brilliant carburet. This shining carburet was then used as a carbonaceous substance for the reduction of an oxyde of iron, but was less efficacious than the same quantity of the charcoal of wood. From these and other experiments, Mr. Mushet considers 100 parts of the so-called marine plumbago to be composed nearly as follows:—

Carbonic acid and moisture .	20
Protoxyde of iron	35·7
Silt, or earthy matter . . .	7·2
Carbon	41·1

Also, he considers 100 parts of the common black lead to consist as follows:—

Carbonic acid and water . .	12·5
Iron	11·5
Earthy matter	4·5
Carbon	71·3

"A theoretical calculation of the Fuel saved by working Steam expansively." By J. W. Lubbock, Hon. M. Inst. C. E. &c. &c.

Fuel saved by expansion.

An equation may be readily formed for the action till the steam is cut off; and the steam being then supposed to dilate into a certain volume, the variation in this volume gives rise to the quantity of action, whence another equation may be obtained, and the maximum of the quantity of action produced by cutting off the steam determined. The quantity of action thus produced is then compared with that produced in any case without cutting off the steam. Now the quantity of heat or fuel expended is proportional to the steam generated in each of the preceding cases, and a proportion, expressing the ratio of the fuel saved to the fuel expended, may be obtained.

"On the Expansion of Arches." By George Rennie, F.R.S.

Expansion of Arches.

The expansion of solids, which has excited the attention of mathematicians since the investigation of La Hire, in 1688, on a rod of iron, is of particular importance in the construction of bridges, the security of which may be affected by the dilatation and contraction consequent on changes of temperature. Periodical motions, referable only to changes of temperature, were observed by Vicat in a stone bridge built over the Dordogne at Souillac, and have frequently been noticed in structures of all kinds. The different expansibility of stone and iron has been considered an objection to the use of cast-iron pillars in connexion with stone to support the fronts of buildings; but the experiments of Mr. Adie of Edinburgh led him to the conclusion, that no danger is to be apprehended from a change of temperature affecting cast-iron and sandstone in any great degree, as their expansion, so far as regards buildings, may be considered the same.

Arguments from this source were employed against the arches of Southwark Bridge, and the experiments set forth in this communication were undertaken with a view of ascertaining the effect of temperature on these arches.

Three sets of experiments were made: the first in Jan. 1818, when the main ribs and diagonal braces rested on their centres, and before any of the spandrils and road plates had been put upon them; the second, in the August and September of the same year. The rise was measured by the insertion of small wedges to about $\frac{1}{40}$th of an inch. The third set of experiments was made on the eastern arch. Three thermometers were employed—one hanging in the open air, another having the bulb immersed $1\frac{1}{2}$ inch in the iron, and the third hanging amongst the ribs; these were observed at different hours of the day, and the results recorded. The rise of the arch was observed by a fine piece of feathered edged brass, nicely fixed to the rib, which by the rise and fall of the arch traversed upon a scale graduated to $\frac{1}{80}$th of an inch. The tables contain experiments on nine days, with the temperatures and rise at every hour of the day. The results, that is, the maximum temperatures and rise, and rise for 1° F. are exhibited in the following table.

No. of Experiment.	Variation in Temperature.	Rise in Arch.	Rise for 1° F.
I.	15°	$\frac{25}{80}$	$\frac{1}{48}$
II.	10°	$\frac{16}{80}$	$\frac{1}{50}$
III.	7·5	$\frac{13}{80}$	$\frac{1}{47}$
IV.	11°	$\frac{22}{80}$	$\frac{1}{40}$
V.	6°	$\frac{13}{80}$	$\frac{1}{87}$
VI.	4·5	$\frac{10}{80}$	$\frac{1}{36}$
VII.	3°	$\frac{9}{80}$	$\frac{1}{26}$
VIII.	8°	$\frac{14}{80}$	$\frac{1}{45}$
IX.	7·5	$\frac{21}{80}$	$\frac{1}{28}$

The mean rise is $\frac{1}{40}$th of an inch for 1° F.

Mr. Rennie then proceeds to calculate the theoretical rise from the expansion of iron, according to Lavoisier, in an arch of the dimensions of Southwark Bridge, for 50° increase of temperature.

The effects of changes of temperature were also observed in the stone bridge over the Thames at Staines. After the arches had attained their full settlement, openings were observed in the joints of the parapets immediately over the springing of the arches, and a distortion or sinking of the upper curve of the parapets. A wedge was inserted into some of these openings, and the lowest point of its descent in the month of January marked. The same wedges were carefully inserted every week until May, when they would no longer enter, and the joints became firmly closed. At this period, however, the joints immediately over the crowns of the arches, which had during the winter been quite close, were now open. From these facts it followed, as a necessary consequence, that in winter the arch contracting descended and the spandril joints opened, and in summer the arch expanding rose and closed these joints, and opened those at the crowns. Thus the joints of the parapets, which were made of single slabs of granite for the whole height, became good indicators of the changes of temperature. It had also been observed, in the Waterloo and other bridges, that joints made good in the winter with Roman cement were found crushed in summer.

With the view of obtaining some data for calculation, Mr. Rennie procured samples of granite, sandstone, and slate, and placing them in a properly constructed oven, ascertained the rates of their expansion, which are given in the paper.

A series of experiments was made at the request of the late Mr. Rennie by Mr. S. Walker, of Rotherham, on the variations in the length of 231½ feet of the frieze, bolted together and laid on a firm platform. The temperature of the atmosphere and of the plates and the length were noted at five o'clock in the morning and at three o'clock in the afternoon, and in some of the experiments at seven o'clock in the evening. The details of these experiments are given in the paper.

The paper is accompanied by calculations for the rise of an arch and the opening at the spandrils for an increased temperature, and also by tables of the expansibility of different kinds of stones and irons given by Distigny.

"Specification and Working Drawings of the Middlesborough-on-Tees Gas Works." By Peter Henderson, Assoc. Inst. C. E.

Gas Works.

In this communication, the author details the several works, erections, and fittings of the Gas Works at Middlesborough-on-Tees, and the mode in which they are to be executed and completed.

"On a mode of Dowelling Timber, or of combining it and other materials for general purposes." By M. J. Brunel, M. Inst. C. E.

Dowelling Timber.

The author proposes to unite timber by means of iron dowels and asphalte. Mastic had been used in the Tunnel works for the purpose of fitting small plates of cast iron to the poling boards. These, though constantly immersed in water and mud, and subject to severe hammering, had stood perfectly well. Asphalte is now used in preference to mastic, as it sets immediately. The author conceives that stone may be united by a similar kind of dowelling; and that wood may be interposed between stone and iron, so as to be used to advantage with the stone blocks, for the chairs of railways. Also, that this method may be used with great advantage in ship-building, in mast-making, and wherever any species of dowelling is required.

Feb. 21.

The PRESIDENT in the Chair.

"On Steam Engines, principally with reference to their consumption of Steam and Fuel." By Josiah Parkes, M. Inst. C. E.

Steam Engines.

The above is the second and concluding communication on this subject; in the former, the generation of steam more particularly was considered; in the present, its application when generated. These are distinct questions, as it is the economy of steam which constitutes the dynamic perfection of a steam engine, whereas it is the economy of heat in supplying that steam which constitutes the perfection of the boiler as an evaporative vessel. These economic properties are totally independent of each other; they may co-exist in a maximum degree, or in very different degrees, and the degree of perfection which any particular class of engines, or which the particular engines of any class possess, is known from the weight of fuel burnt, of water evaporated, and the mechanical effect realized. As long as engines were constructed with but few varieties, or identical in their forms, the performance of one was a sufficient indication of the performance of all; but new forms of engines and new modes of practice being now introduced, a comparison of the performance on the several systems is a matter of deep practical and scientific interest. With the view of effecting this object, the author has collected all the authentic facts within his reach, and reduced them to common standards of comparison.

The effective power of steam engines may be ascertained either from the resistance overcome, or from the load upon the piston by means of the indicator; the former method being applicable to pumping, the latter to rotative engines. But the effective power of the steam in pumping engines, as thus ascertained, is far below the real effective power of the steam, and no exact comparison can be made by these means between the effective power of the steam in the two classes of engines. The useful effect is not synonymous with a true measure of effective power, since the duty is the true useful effect in a Cornish engine. The indicator when applied to the Cornish engines enables us to ascertain the absolute but not the effective power, so as to compare it with that of the rotative engine, since the friction of the engine and the load cannot be separately determined. The absolute power of the steam may also be ascertained from the relative knowledge of the elastic force of steam corresponding with the ratio which the volumes of water bear to each other. This theoretical estimate requires however several corrections; among which the steam condensed by contact with colder surfaces, the steam consumed in filling useless places, and that lost by priming, must be particularly noted.

Measures of Effect.

The relative performance of pumping engines is well expressed by the term "duty," that is, the number of lbs. raised one foot by a given quantity of fuel; and of rotative engines by the term "horse power," that is, the number of lbs. raised one foot in a minute, divided by 33,000 lbs. the standard measure of a horse. The performance of the rotative engine may also be estimated by duty, and of pumping engines by horse power. The results of these computations for several engines are tabulated in this communication.

Expenditure of power.

The sum of the latent and sensible heat being constant for steam of all elasticities, the expenditure of both power and heat is truly measured by the weight of water consumed as steam; this measure is free from all uncertainty, and independent of all theory; the weight of water as steam equivalent to the production of a horse power in each engine, and the duty effected by one pound of steam, will denote the positive and relative efficiency of the steam and the heat. These indices of efficiency being referred to some standard, we learn, from the preceding data, the precise value of each engine in its use of steam and fuel; of its boiling apparatus, as a generator of steam; of the comparative efficiency of the steam and coal, or economy of power and fuel. The results which may thus be obtained are also exhibited in tables, accompanying the communication.

The proportion of Boilers to Engines.

The power resulting from the expenditure of equal weights of water, as steam, being known, the boiler may be connected with the engines, and the relative extent of heating surface employed to furnish their power shewn. It will thus appear that equal measures of surface are quite inadequate to supply equal power, with equal economy, to different classes of engines. These results are tabulated in great detail, and it appears that the Cornish engineers now employ nearly eight times as much boiler surface for equal nominal power as that given by Watt's practice. But taking into account the fuel burnt per horse power per hour in the two cases—the Cornish engine consuming 2½ lbs. per horse power per hour, and Watt's engine 8½—the true relation of the boilers is as 19 to 1. Many other relations of a similar striking character may be deduced from these tables.

Relative economy of engines.

The detailed results of the experiments by Smeaton in 1772, on his improved Newcomen engine at Long Benton—by Watt, in 1786, on his rotative condensing engine, at the Albion Mills, are recorded in these tables; and it appears that the economy of the latter as regards steam and fuel was double that of the former, and approached very nearly to perfection in the use of power obtainable on that principle. The next great advance in the economy of fuel and power is that made by the Cornish engineers, whose performances, both with pumping and rotative expansive engines, far exceed any attained with the common unexpansive condensing engine. The superiority of two of these engines in 1835, doing a duty of 80 millions, exceeds the engines of Watt and Newcomen by 2½ and 5 times in economy of power, and by 3½ and 7 times in economy of fuel.

Standard of comparison.

The obtaining a standard measure of duty is of great importance; a heaped measure, as a bushel of coals, is highly objectionable, as the weight of such measure will vary from 84 to 112 lbs. In the Cornish reports the bushel is fixed at 94 lbs. weight, as the standard of comparison, but some portion of a ton or one lb. would be a better standard. Other combustibles, however, as coke, peat, &c., may be used partially, or to the exclusion of coal, and under these circumstances some other standard of comparison is necessary, and with this view the author suggests a pound of water in the form of steam as the best standard of duty. The work done by a given quantity of water as steam is a sure index of the quality of the steam engine; it is a measure unaffected by variable calorific agents, and so long as engines continue to be worked by steam, so long will the performance of different engines be accurately gauged by their respective expenditure of water as steam. The accuracy of this measure depends on the physical fact of the constancy of the latent and sensible heat in steam of all temperatures. The author has recorded twenty-eight experiments made on twenty-eight different days, on vaporization from the boiling point to 60 lbs. pressure above the atmosphere, which present a remarkable confirmation of the above law, and shew that the relative efficiency of steam in engines is due to the manner of using it, and not to any change in its chemical constitution at different pressures. The manner of conducting these experiments, and the precautions taken to ensure accurate results, are detailed with great minuteness.

Constituent heat of steam.

The author next proceeds to treat of the Locomotive Engine, and to discuss, compare and tabulate the facts relating to this engine in the same manner as he has done those of the stationary class. The qualities of the boiler of the locomotive as an evaporative vessel had been discussed in the first communication. The locomotive differs from the fixed non-condensing engine only in the use of the blast, and the same method of measuring the effects of the steam are applicable to both. Experimenters on the locomotive have generally attempted to determine the amount of resistance opposed to its progress in preference to ascertaining the power expended in overcoming the resistance. The exact solution of either of these questions would furnish all that is wanted; but the ascertaining the total resistance by an analysis of its several constituents is attended with great difficulties, as the forces to which they are to be referred are so exceedingly numerous and variable, that the assigning the exact value to each at any one velocity has hitherto eluded the talents of those who have pursued this method. M. de Pambour was the first analyst whose labours will require attention. The results given by this author in his practical treatise on Locomotive Engines on Railways were compared by Mr. Parkes with the results which he had obtained when experimenting on an engine of precisely a similar character, and discrepancies presented themselves which appeared to-

Locomotive Engine.

tally irreconcilable. These and other circumstances led the author to consider, whether the resistance to traction would properly be deduced from the laws of gravitation, or whether any certain results would be derived as to the amount of resistance on a level from observations on engines and trains moving down inclined planes. The great object seemed to be to discover some criterion of the mechanical effect produced by a locomotive at all velocities, which would apply as practically and as distinctly to a locomotive as duty to a pumping engine, or horse power to a rotatory engine. If this were possible, it seems of far less importance to distinguish the precise value of each particular unit of resistance, than to determine the relative sum of resistance and the relative expenditure of power at all velocities and under all circumstances. Now the term duty may be applied in the strictest sense of the term to the work done by a locomotive engine; for whether the engine drag a load whose resistance is 8 lbs. per ton, or whether a weight of 8 lbs. for each ton of matter moved descending over a pulley and attached to the load, be considered as the moving force, the result is the same. If, then, the tractive force, or resistance per ton of matter in motion, which is the real load on the engine, be ascertained, the whole effect is found by multiplying this sum by the space passed over in feet; and the consumption of water as steam and of coke being known, we have all the elements requisite for determining the duty performed by the steam or coke. The pressure against the pistons may be deduced from the sum of the resistances first calculated on the assumed resistance overcome at the velocity of the engine in each experiment; and the pressure on the pistons may also be deduced from the ratio of the volumes of the steam and water consumed. The results which may be obtained on these principles are tabulated, for the experiments of M. de Pambour, Robert Stephenson, and Dr. Lardner. In another table the author has recorded the reduction of each of these experiments to terms of horses' power, and has exhibited under that denomination the absolute power resulting from the steam used—that required to overcome the assigned resistance—their differences—and the power which balances the gross and useful duty. The construction of these most elaborate tables is described in great detail, and the consequences which follow from the tests thus obtained are fully stated, and the author comes to the conclusion, that results inconsistent with the capabilities of the locomotive are perceptible in almost every one of the experiments. A condensing engine placed on wheels, with water of condensation transported for its supply, and made to drag a train along a railway, would require the same expenditure of water as steam, to produce a given effect, as if fixed; a non-condensing engine also is one and the same machine, whether fixed or locomotive, excepting that the latter must consume more power than the former, to do equal work, at like pressures, by the amount of the additional resistance arising from the contraction of its eduction pipes, in order to produce a fierce blast of steam through the chimney. From these and other causes the fixed non-condensing engine must be the more economical of the two; but if the results derived from M. de Pambour's data be correct, we must acknowledge the fixed non-condensing engine, with its simple atmospheric resistance, to be far inferior in economy of steam to the locomotive, with its plus atmospheric resistance. The experiments by Dr. Lardner were made for the purpose of determining the resistance opposed to progressive motion on railways. They consisted in dismissing trains at various speeds from the summit of inclined planes, and in observing their velocity when it became uniform, the resistance at such velocity being equal to the accelerating force of gravity down the inclined plane. The results of these are tabulated in the same manner as the preceding, and the most singular discrepancies present themselves. For instance, it would appear that in one particular case a duty of double the amount of that effected by the condensing engine was performed by an equal expenditure of power; that compared with a fixed non-condensing engine at equal pressure, the locomotive, though labouring against the heavy counter-pressure of the blast from which the other is free, is assumed to have performed equal work with less than one half the expenditure of power. That if the resistance assigned by Dr. Lardner as opposed to the progressive motion of the train be correct, the efficiency of the steam in the locomotive is more than double that obtained by the best condensing engines; more than treble that derived from stationary non-condensing engines, and equal to the performance of a Cornish expansive engine, doing a 50 million duty with a bushel of coals. With such results before us, the resistances assigned as opposed to and overcome by the locomotive at different velocities, must be regarded as utterly inconsistent with reality, and as resting on no solid foundation.

The preceding results shew also that errors have crept in by the adoption of the theoretical method of reducing undulatory surfaces to a level. M. de Pambour extends the length of the road as a compensation for the acclivities or for the help afforded by the bank engines, and Dr. Lardner diminishes the time of the trip to that which he assumes would be occupied in performing it on a dead level. If the principles on which these corrections for the acclivities and declivities are made be correct, other facts than we are at present acquainted with must be taken into account before it can be demonstrated that a given power will convey a given load at some certain increased velocity along a level compared with the actual velocity along any given undulating line. The resistances which enter into the composition of the sum of the forces are ever varying to such an extent, that it may be doubted whether the theoretical level be not a pure fiction with reference to the practical results of the experiment.

Of Momentum, as a measure of effect.

The effective power of a locomotive engine, or the excess of power after overcoming its proper friction and the resistance from the blast, is solely expended in the generation of momentum. This which is the product of the mass and the velocity represents the useful mechanical effort exerted by the steam, and may always be ascertained under all the practical circumstances of railway traffic. The consumption of power as water, in the shape of steam, is a third quantity which may also be readily ascertained. The application which may be made of the above data is comprehended in the following propositions. First, that equal momenta would result at all velocities from an equal amount of power expended in equal times by the same engine, if the forces opposed to progressive motion and to the effective use of steam in the engines were uniform at all velocities. Secondly, the difference between the momenta generated by a unit of power in a given time at various velocities, measures the difference in the sum of the resistances opposed to the power at those velocities. Having ascertained the gross weight of an engine tender and train—their mean velocity—and the expenditure of water as steam during the trip, simple computations will inform us of

1. The mechanical effect realized by a given power at all velocities.
2. The total increase or decrease of resistance at all velocities.
3. The ratios which the increase or decrease of resistance at different velocities bear to the ratios of those velocities.

Two other results also follow from the above, and which may be termed the commercial results, viz. the amount of gross and useful tractive effect realized by an equal expenditure of power at all velocities. The difference between these is a useless quantity in a practical sense, being the costly waste of power incident to the locomotive functions of the engine and tender over and above the waste arising from the unascertained and ineffective portion of the whole power required for the blast. The reductions and computations necessary for the exhibition and development of these views are contained in two tables. They relate to forty-nine experiments, being those already referred to, and those by Mr. N. Wood, on the Great Western, and London and Birmingham Railway, and some others. One of these tables contains the velocity of the engines, the consumption of water as steam, the loads, the absolute momenta per second; the momenta generated by equal power in equal times, viz. by 1 lb. of water as steam per second; the weights of the gross and useful loads moved by equal powers, viz. by one cubic foot of water as steam, at the velocity of each experiment, with various other elements. The other table contains a summary of the ratios of the velocities and of their squares, brought into juxta-position with the ratios of the power expended to produce equal momenta, equal gross and equal useful effects, by the comparison of pairs of experiments on the engines given in the preceding table. This table also shews the influence of velocity in the expenditure of power to produce equal mechanical and equal commercial effects; and the amount of loss attributable to the increase of resistance at the higher velocities. The author discusses in great detail the various circumstances of these experiments, and the inferences and practical conclusions which may be deduced therefrom: and comes to the conclusion, that the determination of the performance of locomotive engines by the methods here set forth is as practicable, exact, and demonstrative of their relative powers and dynamic excellence, as the determination of duty done by pumping engines.

The Blast.

The intensity of the pressure on the opposite side of the piston arising from the blast has been but imperfectly stated. By some the discharge of the steam has been likened to a jet, and considered continuous. But an attentive observer can appreciate by his ear that an interval exists between the alternate discharges of steam from the two cylinders. That these jets are periodic and not continuous, is also distinctly evidenced by the audible pulsations in the chimney, even at the very highest velocities of an engine, and their duration may be measured at lower speeds. Upon this intermittent action of the blast depend, in a great measure, the resultant pressure against the piston, and the production of a sufficient current of air through the fire, both which effects would be materially changed in intensity by the substitution of a continuous for a periodic current. The precise duration of the jet or of the time of the steam evacuating the cylinder, can only be determined by direct and careful experiments; but its period may be ascertained within definite limits; for since a single discharge is completed within the time occupied by the piston in accomplishing a half stroke, and the pauses between two successive discharges are distinctly perceptible, a single blast cannot occupy the fourth part of the time of the revolution of the crank shaft, and very probably does not exceed the eighth part, or the period of a quarter stroke of the piston. Under no circumstances, then, can the pressure from the blast oppose the piston much longer than during one fourth of the stroke.

With an active pressure, then, of 30 lbs. per square inch, the mean resistance from the blast would not be greater than 7½ lbs., and with a pressure of 15 lbs. not greater than 3¾ lbs. per square inch, against the pistons. The author then proceeds to cite several observations and experiments made by himself, which are confirmatory of the preceding argument respecting the blast, and he was led conclusively to the fact, that ⅕th of the power of the engine experimented upon, at working pressures of 20 lbs. and 15 lbs., was absorbed in blowing the fire; and that the escape of the steam from the cylinder was 4 times swifter than the motion of the piston.

Fixed and Locomotive non-condensing Engines.

The author lastly treats of the expenditure of power for a given effect by fixed and locomotive non-condensing engines. But few experiments on the expenditure of steam for a given effect by non-condensing stationary engines have been made. The relative consumption of fixed condensing and non-condensing engines has been treated of by the late Mr. Charles Sylvester, of Derby, whose knowledge and accurate theoretical analysis of the subject are shewn by the close accordance of his conclusions with the facts established on two engines of these classes at certain working pressures. His conclusion that the relative economy of these engines will be as the quantities of steam consumed, or as 1 to 1·72, at those pressures, is accurately confirmed by the results here recorded. Mr. Sylvester also shewed, that by increasing the pressure upon the same non-condensing, and by enlarging the area of the condensing engine's cylinder and air pump, so as to maintain the steam in it at a uniform pressure per square inch for all loads, the economy of the former would gradually approach and finally equal that of the latter. The results obtained in the preceding part of the paper furnish numerous comparisons between the locomotive and fixed non-condensing engines, and the consumption of the latter has been used, together with the condensing engine, as the test of the accuracy of the data of resistance assigned to the former by the various analysts. The accurate determination of the expenditure of steam by the same locomotive engine, in which the values of the friction and of the blast pressure were ascertained, admits of the consumption of water as steam for given effects being determined, and thus narrows the grounds of doubt, and establishes more correct data for ascertaining the real resistance opposed to progressive motion on railways. The application of these principles, as borne out by the experiments of the author, and their particular bearing on the experiments which have been the subject of the previous ample and detailed discussion, form the conclusion of Mr. Parkes's series of communications on steam boilers and steam engines.

Duty and Effect.

The abstract of Mr. Parkes's communication having been read, Mr. Enys remarked, that Mr. Parkes had adopted a different unit of power to the one he was accustomed to employ: but that was a point on which he was not disposed to insist, and he was prepared rather to yield to Mr. Parkes's opinion where they differed. Agreement on terms was very important, and he wished to see more accuracy introduced in the use of certain terms relating to engines; he would confine the term 'duty' to the net work, and the gross work he would call 'effect.' In speaking of a locomotive engine, he conceived the goods carried to constitute the duty—the whole mass moved, the effect. The duty in Cornwall is a theoretical term, being the water which ought to be raised according to the column displaced, but the whole of which did not reach the surface; and the whole mass of pump work, water, &c., set in motion is the effect. The duty is not commensurate with the effect, as it is independent of friction and other expenditure of power. The pit-work is not always well executed, and is not under the care of the engineer. Duty in Cornwall is, in fact, entirely a commercial question, it having been instituted as a check between the adventurers and the engineer who originally undertook to perform the work of pumping for a certain share of the saving of fuel to be made. There were three distinct causes of improvement in Cornwall, viz. in the boilers, in the application of highly expansive steam, and in the pit work.

Engine at Old Ford.

Mr. Wicksteed, in reply to a question as to the work now being performed by the engine at Old Ford, stated the general result to be, that with small Newcastle coals of inferior quality, and of such a size as to pass through a screen of three-quarter inch mesh, the duty amounted to 71 millions raised one foot high with 94 lbs. of coal. He had experienced great difficulty in procuring good Welsh coal, but with some Merthyr coal he had recently tried, the duty immediately increased to 91 millions.

In the Old Ford engine, the steam is cut off at one-third of the stroke, and the water is raised by the weight of a mass of iron acting on the water at the return stroke. With the ordinary valves there is a loss of about one-tenth, but with the valves invented by Messrs. Harvey and West, used in the Old Ford engine, there is no loss and no perceptible blow from the water on the valves closing, although no air is admitted beneath.

Effect of rate of working.

The speed of this engine varies from one stroke to ten per minute, according to the demand for water. In Cornwall, it is thought that at slow speed there is a considerable saving of fuel, but he is of opinion that there is no difference in duty at a fast or slow speed, provided there is sufficient time for opening and shutting the valves.

Duty.

As to the term duty, although it is important to know what is the absolute quantity of water raised, yet that is not the whole effect. The engine raises a certain weight of rods, which is its load, and this weight should, in the return stroke, produce a certain given effect in water brought to the surface; but, owing to bad valves, leaks in the pumps, and other causes, the quantity of water raised is not equal to the calculated amount. We cannot say that an engine has not done its duty because a portion of the water is lost. Two engines, equally good and of identical power, may not produce equal results; because one may be raising water close beneath the beam; another, up a shaft at some considerable distance, by means of a series of long horizontal motioned pump rods; the latter, again, may be doing a duty of 20 millions in working the pump rods only.

It was his intention shortly to present to the Institution a complete report of the work done by his engine, with drawings of every part; but he was waiting to have the opportunity of ascertaining the evaporation from the Cornish boilers as well as from those of a pumping engine of Boulton and Watt's, also in use at Old Ford, so as to determine at the same time the respective duty and consumption of steam by the two engines.

Duty and Effect.

Mr. Field insisted on the importance of distinguishing between the duty and effect, by using the former term for the water actually raised, and the latter for the real power expended. He understood these terms to be so applied to engines for water works in London, and that effect included the friction of the water in the pipes and all other causes of diminution of duty. The real effect should be ascertained from the pressure of the water at the pump, as determined by a mercurial gauge. It is generally understood that, in speaking of the real comparative effects of the water works engines in London, it would be unfair to take the water raised, as the same power would in one case be expended in raising water 100 feet, as is expended in another case in raising water 200 feet. The pressure of the water at the pumps is the proper standard of comparison.

Mr. Parkes stated, that in his paper he had used the term duty as distinguished from the absolute power of the engine. The same Cornish pumping engine at different periods performs very different amounts of duty, although the absolute power exerted by the steam is the same. This arises from additions to the friction by new pump rods, and from other causes. The Cornish result is below the real duty done by the engine, taking the term in their acceptation of it, and using their mode of calculation for that which is by them considered a purely commercial question. The only correct manner of ascertaining the absolute power exerted by pumping engines, so as to compare them with rotative engines, is to take the pressure on the piston and the value of the vacuum on the other side at the same time. The term duty expresses the true, useful, or commercial performance of the engine, but is no measure of the absolute power of the steam which has to overcome the friction of the engine, pumps, rods, &c., in addition.

Best speed.

Mr. Enys, in reply to a question from Mr. Gordon as to the speed at which an engine is worked with the greatest economy, stated the general opinion in Cornwall to be in favour of about 9 strokes per minute; if there was a pause of half a second between each stroke, the Cornish engineers were perfectly satisfied. The indoor stroke is usually at the rate of from 250 to 260 feet per minute, and the outdoor stroke about 140 feet. When the number of strokes exceeds 9, the balance requires to be altered; the engine then runs out quicker, but requires a greater expenditure of steam to bring it in again. In answer to a question relative to Woolfe's engines, he believed they had never had a fair trial, as all the boilers originally adapted to them were much too small, and the tubes soon got full of oxide and mud; if the present system of Cornish boilers had been in use at the time, he thought they would have acted much better. Some engineers are so much impressed in their favour, that they are desirous of giving them a trial again with all the recent improvements.

Mr. Cottam mentioned an engine on Woolfe's principle which had worked perfectly well for several years. It is now grinding a bushel of corn with a fraction less than 4 lbs. of coal. The pressure of the steam in the boiler is from 22 to 25 lbs.

Feb. 11, 1840.

The PRESIDENT in the Chair.

The following were balloted for and duly elected:—John Green, John Hartley, as Members; Joseph Woods, Frederick Rumble, as Graduates; Oliver Lang, John Grantham, Capt. George Smith, R.N., Lieut. E. N. Kendall, R.N., as Associates.

"A Description of the Coffre Dam at the site for the new Houses of Parliament." By Grant S. Dalrymple.

Coffre Dam at Houses of Parliament.

The works described are those which necessarily precede the erection of the main building. They consist of the coffre dam, river wall, and the foundations of the river front—according to the designs, and under the direction, of the engineers (Messrs. Walker and Burges) and Mr. Barry, the architect; the whole being executed by Messrs. Lee, the contractors.

The mud at the site of the works varied much in depth and in consistency, but beneath it is a bed of red gravel and sharp sand, averaging 14 feet in thickness, laying over a stratum of stiff clay, into which the piles are driven to a depth of 2 feet. To facilitate the driving of the piles, a curved trench, 27 feet wide by 8 feet deep, was dredged in the line of the dam. The main piles of Memel fir, 36 feet long by 1 foot square, were then driven, leaving their tops 4½ feet above the Trinity high-water mark of ordinary spring tides. The waling pieces were then attached, and the outer sheet piles of whole timber, 36 feet long by 13 inches square, sawn square on all sides, so as to ensure the joints being close when driven and bolted to the waling. The inner sheet piles of half timber were then driven to the same depth as the others; the space above them was made up with horizontal pieces, bedded down to them, and secured with bolts to the furring pieces inserted above the waling at each gauge pile. The whole length of the dam was secured by diagonal braces, extending back to the old river wall, against which they were abutted. The outer and inner rows of piles were secured together by three rows of wrought-iron bolts, the lower being 2½ inches diameter, and the two upper rows 2 inches diameter. The whole of the piles being driven, the space between was cleared out down to the clay substratum, and then filled up with stiff clay mixed with a portion of gravel; a portion of the excavated matter was then laid on both sides of the dam to protect the piling from injury.

The first pile was driven on the 1st of September, 1837, and the dam was closed on the 24th of December, 1838. The extreme length of the coffre dam along the river face is 920 feet, and the ends return at an angle until they meet with and enter the old river wall, at a distance of about 200 feet from the face of the dam.

The excavations for the foundation of the river wall were got out in lengths of 50 feet, levelled to receive the footing courses, which were laid on a bed of concrete of a thickness varying from 1 foot at the north end to between 5 and 6 feet in the centre and south corner, where the substratum was loose and spongy. The concrete was composed of 6 measures of gravel and sand to 1 of ground lime from the lower stratum of the chalk formation. Along the face of the wall was driven a row of elm sheet piles, from 8 to 12 feet long by 8 inches thick, square sawed, so as to drive close, spiked to an oak wale, and the whole secured to the front by 1-inch wrought-iron bolts, placed at distances of 4 feet apart, stretching back 6 feet into the wall, and fixed by cast-iron washers bedded between the footing courses. The two bottom or footing courses of the wall are 11 feet wide, of York landing, 6 inches thick; on these are two courses of Bramley-fall stone, each 1 foot 3 inches thick, from which rises the stone facing of the wall, of Aberdeen and Cornish granite, in courses varying in thickness from 2 feet 2 inches at the bottom to 1 foot 7 inches at the top. The front is built to a curve of 100 feet radius, and is backed with brickwork, making the total thickness of the wall 7 feet 6 inches at the bottom, and 5 feet at the top. Counterforts, projecting 3 feet 4½ inches by 3 feet 9 inches wide, occur at intervals of 20 feet along the whole length. At a distance of 28 feet 9 inches from the back of the river wall is the foundation of the front wall of the main body of the building, the space between the two walls being filled up with concrete, composed of 10 parts of gravel to 1 part of ground lime. The total length of the river wall, at the present level of 2 feet 3 inches above the Trinity standard of high-water mark, is 876 feet 6 inches. The wings at each end, projecting 2 feet 3 inches before the face of the centre part, are 101 feet 6 inches long each, leaving a clear terrace walk, 673 feet 6 inches long by 32 feet wide, between the wings and fronting the river. The height of the wall from the bottom of the footing courses is 25 feet 9 inches.

The excavation for the wall was commenced on the 1st of January, 1839, and the building of it was commenced in March of the same year. The amount of the estimate for the dam and wall was £74,373.

"On Browne's Patent Hydraulic Level." By A. F. Hemming.

New Hydraulic Level.

This instrument, designed for ascertaining the relative heights of points not visible from each other, consists of lengths of water-tight flexible tubing, attached to each other by brass joints, and having glass vessels at each end. The vessels and tubing being nearly filled with water, the level of the water, as seen in these vessels at two points whose relative heights are to be compared, will serve to indicate their positions, whatever may be the inflexions of the tubing betwixt the two vessels. Graduated rods are placed perpendicularly at the points of observation, and the lower vessel is raised, and the higher lowered, until the level of the fluid therein intersects the graduation of the rods. It is conceived that this level may be peculiarly useful in mines and excavations, and in fixing complicated machinery.

Light for Lighthouses.

Captain Basil Hall briefly explained his views as to obtaining for lighthouses all the advantages of a fixed light by means of refracting lenses in revolution.

The difference between a fixed and a revolving light is much in favour of the revolving light, as the light can be concentrated and great brilliancy obtained on any particular point at each succeeding flash;—by a fixed light being meant one in which the light is visible on every side; and by a revolving light, one in which the light appears in periodical flashes. Fresnel's fixed light has only one-sixth the brilliancy of his revolving light. Fresnel's system consists in having a large central lamp with four concentric wicks, surrounded by eight lenses, each three feet diameter. The light is thus concentrated and thrown off in eight pencils, which, as they strike the eye successively, have very brilliant effect, and are visible at a great distance.

Captain Basil Hall's inquiries have been directed to ascertain whether the well-known superior brilliancy of a revolving light could not be obtained for a fixed or continuous light; that is, for one equally visible in all directions at the same moment. His idea was, that by giving a certain velocity of revolution to a series of lenses round a fixed light, as in Fresnel's arrangement, a continuity of illuminating power, equal almost in brilliancy to that of a slowly revolving light, might be produced. This, he expected, would prove true, provided no intensity were then lost. He had erected some apparatus at the Tower, and determined the effect by experiment. The apparatus consisted of a fixed central light with a series of eight lenses, 1 foot diameter and 3 feet focal distance, so arranged as to revolve at any velocity up to 60 revolutions per minute. The light from the central lamp being concentrated by refraction through the eight lenses into eight pencils, having a divergence of about 8° each, illuminated not quite 50° of the horizon when at rest; but when this same system of lenses was put into rapid motion, every degree of the 360° of the horizon became illumined, and to spectators placed all round the horizon, the light would appear continuous and equally brilliant in every direction. The only question would be, whether or not this continuous light is essentially less intense than the light seen through the lenses at intervals when in slow motion. The fact is, that two distinct effects are produced in this experiment—a physical effect in diminishing the brilliancy of the light exactly in proportion to the ratio of the dark portion of the horizon compared to that of the enlightened portion, viz. as 310° to 50°; and a physiological effect (suggested by Professor Wheatstone), by which the sensibility of the retina might be so excited by a succession of bright flashes, that not only a continuity of light might be produced, but a light not much, if at all, inferior in intensity to that caused by the lenses at rest. When first set in motion, the effect is that of a series of brilliant but trembling flashes; as the system of lenses is accelerated in velocity, the steadiness of the light increases with scarcely any apparent diminution of brilliancy. At 44 revolutions per minute absolute continuity is produced, and at 60 revolutions nearly the steadiness of a fixed light. When viewed from the distance of half a mile, the effect is nearly that of continuity, very much resembling that of a fixed star of the first magnitude. The only difference in the quality of the light is, that the lenses being in motion, it resembles a star twinkling violently; and when at rest, it resembles a planet. The difference of intensity had been measured by examining the light through a number of plates of stained glass. Some eyes had seen the light through 13 glasses, the lenses being at rest—and through 12, the lenses being in motion; other eyes with other glasses had seen it through 10, the lenses being at rest—and 8, the lenses being in motion. He had seen it through 9, the lenses being in motion, and through 10 at rest. He did not pretend to say whether mechanical difficulties might not prevent the adoption of the system; what he aimed at was to establish the principle, that by putting a system of lights into a rapid rotary motion, a continuous light visible in all directions would be the result, without any essential diminution of brilliancy, as compared to that of the same lights when viewed at rest. If this principle should prove correct, its application to practice might afterwards be thought of, and left to the ingenuity of the engineer; but if the principle should not be correct, and there was a great loss of light by the rotary motion, then it would be useless to go on.

Feb. 18, 1840.

The **PRESIDENT** in the Chair.

The following were balloted for and elected:—Henry Chapman, Alexander Macintosh, as Graduates; Joseph Horn, Robert Sinclair, Captain P. W. Willis, B.E., Captain Chappell, R.N., as Associates.

Duty of Engines.

Mr. Cottam, in reference to the discussion of a preceding evening (Feb. 4), on the duty of engines, alluded to the pumping engine at Hammersmith, which forces the water through five miles of pipes, and then through a vast number of smaller pipes, and was subject to great variations of service, and inquired how the duty could be ascertained with any tolerable accuracy, as the variable expenditure of steam under different circumstances must lead to considerable errors. If a boiler, as in the Cornish engines, is adapted to raise the bob 7 times per minute, and owing to some cause, as the water not being able to get away, the bob is raised only 5 times per minute, there is two-sevenths in favour of the boiler; or if an engine adapted for 30 strokes per minute makes only 25 occasionally, there is great difficulty in comparing it with other engines.

Mr. Donkin urged the necessity of keeping the quality of the engine and its commercial effect perfectly distinct; if a given weight be raised to a given height, it must produce a given effect minus the friction; in water-works engines the resistance opposed by the friction is very considerable, and being very variable, it must not be allowed to interfere with the consideration of the intrinsic quality of the engine; of two engines having equal power, one may discharge, owing to these circumstances, more water than the other, but if both be of the same construction and raise a given weight, whether the water be discharged perpendicularly or forced through any length of horizontal pipes, there can be no mistake as to the amount of the effect produced, or, in other words, of duty performed, as that would be determined by the weight raised if in a Cornish engine, or by the resistance overcome if in an ordinary pumping engine.

Mr. Wicksteed observed, that there was no difficulty in instituting a comparison between the duty of a Cornish engine and of an ordinary water-works engine, because by the former the water was raised through a perpendicular shaft, and by the latter forced through several miles of pipes, of varying length and resistance. He had for several years ascertained, by means of a mercurial syphon gauge, the pressure at the pump piston, and this gave with perfect accuracy the resistance overcome by the engine, whether arising from the pressure of water raised to a given or varying height, or from the friction in a great length of pipes. This was easily proved at Old Ford, where the water was raised into a perpendicular column or stand pipe, in which the level of the water would be that necessary for overcoming the resistance opposed by the pressure and friction. In making comparisons between the common water-works engine and the Cornish, this was the mode he had adopted, and he believed it to be the only fair one. He had proved the accuracy of the mercurial gauges by the measurement of the column of water supported. The Cornish engine at Old Ford acts by raising a weight of metal, which upon its return raises the water. This is the only engine in London of the kind, and to establish a comparison between it and any other pumping engine, it is only requisite to apply a mercurial gauge as just described to the pump of each, and whether the water is lifted direct or forced through any length of pipes, the resistance or load against which the steam acts will be shewn. Previously to his Cornish engine being set to work, the beam and plunger were balanced with the greatest accuracy, and their preponderance ascertained before the steam piston and plunger were packed. The weight afterwards added to the pump end was also carefully ascertained. The weight raised at each stroke of the engine is thus accurately known. The number of strokes performed in a given time is registered by the counter. The coals are carefully weighed. By ordinary attention, the boilers are so managed with regard to the work to be done, that no steam is allowed to blow away whether the engine be making 3 or 9 strokes per minute; and in calculating the duty done by the quantity of coal consumed, no deduction is made for stoppages. Thus, a certain number of strokes being made, a known weight has been raised to a given height a given number of times by the consumption of a known weight of coals. This engine worked under the pressure of a column of water from 110 to 116 feet in height, and the water was forced through 300 miles of pipe, varying from 42 inches to 3 inches in diameter. The load at the pump in the common pumping engine is ascertained by the same means, and no error can exist in determining the duty performed by each.

Mr. Parkes observed, that the term duty did not seem to be quite understood; duty was not the weight of water raised 1 foot in height, but that weight divided by a bushel or other measure or weight of coals also; that the time in which the water was raised did not enter into the computation of duty, though it did into the determination of horse power. He would again call attention to the fact, that coal was no measure of power or of the quality of an engine; that one engine might be doing more duty than another, because it had better coal or better boilers; and that the only standard of perfection between different engines was the relative consumption of water as steam for equal effects.

Revolving Lenses in Light-houses.

Mr. Parkes observed, that he could entirely confirm the account of the experiments with revolving lenses given by Captain Basil Hall on a preceding evening. It appeared to him, that when the lenses made 32 revolutions, the light was not quite continuous; but at 40 revolutions it was perfectly so, although the general effect was twinkling. The central spot was very distinct; he saw the light equally as distinctly through 10 coloured glasses, the lenses being in motion, and through 11, the lenses being at rest. He would suggest, whether the tremulous appearance of the light might not be in part accounted for by the slightness of the revolving frame, which at the required velocity vibrates considerably. In the temporary apparatus erected at the Tower, one man could maintain about 40 revolutions per minute.

Mr. Alexander Gordon remarked, the coincidence of the experiments of Captain Basil Hall with a law of light as laid down by writers on optics,—viz. that if a luminous body pass the eye eight times in one second, the impressions are blended so as to produce the appearance of continuity, or that the duration of an impression on the retina may be taken at about eight seconds. Now, in the apparatus erected by Captain Basil Hall, there are eight lenses, and continuity of light is produced when the frame makes 60 revolutions a minute. Thus, eight lenses flash across the eye in one second, and the observed result is a remarkable confirmation of the law alluded to.

Mr. Hawkins thought the light was better and steadier at 40 revolutions than at any other speed. When observing the reflection of the light on the features of the by-standers, he saw them very distinctly, the lenses being at rest; but from the moment of commencement of motion, there was a visible diminution in the intensity of the light, which increased with the speed. He saw the light, the lenses being at rest, through 10 coloured glasses, and through 9 when in motion.

Mr. Macneill thought the light was steadier at 60 than at 40 revolutions. The shadow was less intermittent. He did not conceive the mode of examining the intensity of the light through coloured glasses to be so correct as by observing the depth of the shadow, as the eye was capable of judging more correctly of the relative intensity of shadows than of lights. When the lenses were in rapid motion, there appeared a dark spot in the centre of a luminous disc.

Professor Keating, of Philadelphia, stated that the dark spot in the centre appeared as if he saw the wick of the lamp. The lenses being at rest, the light was uniform; but on their acquiring a certain degree of velocity, its whiteness diminished; until at 40 revolutions a decided orange tint appeared, and at 60 revolutions both the orange hue and the centre dark spot increased.

Mr. Lowe inquired whether the quantity or intensity of light was most required for lighthouses. The conflicting opinions of experimenters on the intensity of light, as ascertained by the photometers now in use, shew that some better test or means of comparison is wanted. He should conceive that pieces of coloured glass could not afford any accurate measurement of the space-penetrating power of light at so small a distance as 345 feet, which he understood was the length of the room in which these experiments were tried. The depth of shadows also furnished no adequate measure of the intensity of light, for shadows were differently coloured for different lights. Perhaps, the photogenic paper might furnish the tests and means of comparison now so much wanted.

The President remarked on the advantages of the revolving lights, as apart from the greater brilliancy, in that they are peculiarly useful as being easily distinguished from land and other lights, which tend to mislead mariners. There may be peculiar advantage in the tremulous character of Captain Basil Hall's light, as enabling it to be more easily distinguished among others. It is not simply the quantity of light which is diffused over the horizon which is valuable, but the intensity of the ray in a certain direction, which, falling on the eye, rivets immediate attention.

Feb. 25, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—William Reed, Captain Andrew Henderson, Edward Oliver Manby, William Johnson, Alfred King, and Gustave Holtze, as Associates.

"On the improvement of navigable Rivers, with a description of a self-acting wasteboard at Naburn Lock, on the river Ouse." By Henry Renton, Grad. Inst. C. E.

Previously to the year 1834, the navigation of the river Ouse from Selby up to Boroughbridge, a distance of 39 miles, was much impeded by a number of shoals or 'huts,' some of them of considerable extent—all vessels drawing more than 5 feet water being compelled to await until the spring tides set in, so as to afford them sufficient depth of water. Mr. Rhodes was consulted as to the best mode of obviating this difficulty. He recommended the employment of a steam dredging-machine to deepen the bed, by removing the shoals, and the construction of a self-acting wasteboard on the dam, so as to give an additional height of water between Naburn and Linton Locks, as it was found that no injury could occur in the adjacent lands from the level of the river being raised 18 inches.

The greater part of the shoals consisted of compact blue clay, with a mixture of gravel and large boulder stones, and, in a few instances, of oak trees, such as are found near the bottom of bogs.

To use the dredging-machine in the most advantageous manner, the principle of the sliding tool in a turning lathe was adopted, by running the machine across the face of the shoal from side to side of the river, without altering the position of the lower tumbler. This method produced a perfectly even horizontal surface of the bed, and prevented subsequent accumulation. The whole of the shoals were thus removed, so that sea-borne vessels and steamers, drawing from 11 to 12 feet water, could at all periods navigate to York, a distance of 80 miles from the Humber. It was still necessary to raise the height of the water at least 18 inches between Naburn and Linton Locks, to enable vessels drawing 7 feet water to pass at all seasons from York up to Boroughbridge, a farther distance of 20 miles. To accomplish this, the self-acting wasteboard was constructed.

It is composed of two distinct boards of Memel timber, each 76 feet long, 18 inches high, and 4 inches thick, placed on the top of the angular face of the dam. It is fixed by means of strong wrought-iron hinges, leaded into the stone work at intervals of 10 feet. Over the hinges are fixed wrought-iron bolts, 1 inch diameter, connected by flat chains with the plimmer blocks on a line of shafts extending behind each board on the face of the dam; on the ends of these shafts are fixed spur-wheels working into pinions which drive pulleys, over which run the chains supporting the balance weights, which are hung on the face of the wing walls. When the balance weights are at the bottom of the walls, the wasteboard will be in an upright position, which occurs when the surface of the water does not rise 6 inches above the top of the boards or 2 feet above the dam; but when, on a sudden increase of the volume of water, there is a considerable pressure on the face of the wasteboard, it more than counterbalances the weights, and causes the boards to incline towards a horizontal position, at the same time raising the balance weights and allowing a free passage for the water. When the pressure diminishes, the weights descend and the boards resume their vertical position.

The time occupied in dredging the river and constructing the wasteboards was two years, and the cost of the latter, which was made by Messrs. J. and W. Lailder, of York, was £300.

The result of these alterations has been most satisfactory, as since their completion not a vessel has been detained in the upper level, and the registers of the heights of the water at Linton and Naburn Locks and York shew, that the winter floods have not risen to such a height, or continued for so long a period, as previously to the improvements being carried into effect.

"On the autogenous uniting of Lead and other Metals." By M. Delbruick.

The term 'autogenous' is employed by the inventor, M. de Richemont, of the method now described, to designate the union of pieces of metal of the same kind with one another without the intervention of the ordinary alloys of tin or other connecting medium. This is effected by directing, by means of a fine beak, the flame of a jet of hydrogen on the parts to be united. A complete fusion of the metal is thus effected, and the parts are united in one homogeneous mass, the metal at the points of junction being in the same state chemically as at the parts untouched. Plates of any thickness, whatever the direction of the edges to be joined, may thus be perfectly united, and the lines of junction made as strong as the rest of the mass. Many circumstances contribute to render the joints made with common solder objectionable. The rates of expansion and contraction on changes of temperature for lead and its alloys with tin are different; some chemical agents act much more on alloys of lead and tin than on lead alone. The alloys also are fragile, and the solder may not perfectly attach itself, without the imperfection being observed. In addition to obviating these objections, M. de Richemont conceives that his new method of union possesses the farther advantages of economy, in saving of solder and in avoiding seams and overlappings; in permitting the use of thinner lead and the use of lead where it is now inadmissible, and in rendering practicable the repairs of vessels which are now impracticable.

M. de Richemont also applies this jet of flame to heating the common soldering irons used by tinmen and plumbers. The jet is permitted to play upon the tool, which in a few seconds is brought to the requisite heat, and maintained at that heat without any injury to the tool. The heat can be regulated to the greatest nicety by diminishing or increasing the jet. The author conceives that the sulphate of zinc produced in the manufacture of the gas will be found of such value as greatly to diminish the cost of this process.

March 3, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—Robert Napier and Daniel Mackain, as Members; John Salkeld, Robert Batson, John Gandell, and Siegerick Christopher Kreeft, as Graduates.

"Description of the 'Nonsuch' Iron Passage Boat plying on the Limerick navigation, between that place and Killaloe." By Charles Wye Williams, Assoc. Inst. C. E.

The attention of Mr. Williams having been attracted to the successful plan for the conveyance of passengers adopted on the Glasgow and Paisley Canal, where light sheet-iron boats of great length travel at a speed of nine miles an hour, he was induced to attempt the introduction of the same system on the Irish canals. A great difficulty, however, presented itself, as the locks there would only admit boats 60 feet long, which length was quite inadequate to the carrying out with advantage the principle involved in the long light Scotch boat. To overcome this difficulty, he constructed a sheet-iron boat, 80 feet long and 6 feet 6 inches wide at midships, having the stem and stern ends (each 10 feet long) attached by strong hinges to the body, and susceptible of being rapidly raised to a vertical position by means of winches; thus reducing the length to 60 feet when required to pass through a lock. It is evident that by this means there would be gained not merely the apparent additional buoyancy of 10 feet at each end of the boat, which from the form would not be very effective, but in reality the buoyancy due to an addition of 20 feet of the midship section. The boat thus constructed has been found to answer perfectly; the buoyancy is equal to that of the Scotch boats of similar dimensions; no crankness or unsteadiness accrues when the ends are raised; it is capable of carrying 60 passengers, travelling at a speed of 9 miles per hour, with the same power that was required to draw a 60 feet boat with a less load, and there is a much less action on the canal bank in consequence of the increased length, which at the same time imparts stiffness, and enables passengers to enter and leave the boat with safety. Considerable time is saved in passing the locks, by the opposition of the square end when the bow is raised; the boat may thus be run almost at full speed into the lock, and both ends being raised simultaneously, it is stopped much more easily than if the tapered ends were down. No provision is necessary for keeping the ends down, as the weight of the bow and steersman answers the purpose.

This boat has been working without intermission for three years between Limerick and Killaloe, traversing twice daily a distance of 15 miles, on a navigation of considerable intricacy, and passing 11 locks, without any accident having hitherto occurred.

Mr. Parkes observed that, independent of the advantages of carrying more passengers, by continuing the midship section to the length of 60 feet, considerable speed was gained by the 80 feet boat, in consequence of its fine entrance and run. Mr. Williams informed him that the velocity was found to depend on the position of the boat on the wave; that the rider of the horses employed in towing the boat knew exactly the proper position of the wave with respect to the boat, and regulated the exertion of the horses accordingly—the velocity of the boat and the tractive force depending on the relative position of the boat and wave.

Mr. Field, in reply to some remarks respecting the effect of these rising ends on the buoyancy of the boat, stated that he did not understand it to be Mr. Williams's design to obtain additional buoyancy thereby. The ends only press on the water as much as is due to their own weight, and are principally useful in giving a fine entrance and run to the boat; thus having the whole space between the rising ends for the accommodation of passengers, and obtaining an absolute gain of the whole space that is lifted at each end, as in a boat of the ordinary length there must be the same tapering of the bow and stern ends. So great is the facility in managing the ends, that on quitting a lock the bow end is lowered as the gates are opening; the boat is set in motion at the same time, and as it moves on the stern end is let down, and the usual speed is obtained very soon after it clears the lock. When a lock is to be entered, the boat is suffered nearly to reach the gate at full speed, when the bow end being raised, the additional resistance caused by the square section being suddenly opposed to the water stops the boat almost immediately. The weight of one man at each end is amply sufficient to keep down the ends when the boat is in motion.

"On the experiments and results of Mr. W. J. Henwood, as to the power of the Huel Towan Engine." By George Woods.

Huel Towan Engine Experiments.

In this communication, the author refers to the experiments of Mr. Henwood, published in the second volume of the Transactions, and to the result there stated, that the curve traced by the pencil of the indicator during the expansion of the steam deviates from a true parabola, according to the temperature of the medium contained in the jacket. Mr. Woods comes to the conclusion that, the temperature remaining constant, the curve will deviate very considerably from a true parabola. The results obtained by the author as to the relative powers of the engine before and after the steam is cut off, and the mean pressure as given by the indicator diagram, do not differ materially from those given by Mr. Henwood. But Mr. Woods differs from Mr. Henwood as to that portion of the curve which the latter selects as representing the true value of expansive working.

"Description of a Running Gauge for ascertaining the Parallelism of a Railway." By Edward Cowper.

Gauge for Railways.

The construction of this gauge somewhat resembles that of a truck, having two grooved wheels made to fit the rails on which it travels. It has two axles, one of them fixed and the other moveable, so as to accommodate itself to any variation in the width between the rails: to the end of the moveable axle is attached an arm, which, by its vibration across a dial, points out the degree of irregularity in the parallelism of the lines of rails. It can be used by hand or attached to the end of a train of carriages, and is intended as a rapid mode of detecting any irregularity in the railway.

"An Azimuth Cap as an addition to the common Level." By Edward Cowper.

Azimuth Cap for Levels.

It is sometimes desirable in levelling operations to ascertain the bearing of objects which are either above or below the field of view of the telescope. The common level alone cannot take the bearing of such objects; for, by elevating or depressing the telescope, the action of the compass is destroyed; but, by slipping the Azimuth Cap on to the end of the telescope of the level, objects 50° above or below the field of view may be observed without disturbing the compass or altering the level of the telescope.

This instrument consists of a brass cap containing two slips of looking glass placed at an angle to each other, precisely as in Hadley's quadrant; one glass being fixed at an angle to the axis of the telescope, and the other being moveable about a centre. When any object is required to be brought within the field of view, the cap is placed on the end of the telescope, and the angle of the moveable glass is varied until the object is reflected on the fixed glass, and thence to the eye.

March 10, 1840.

The **PRESIDENT** in the Chair.

The following were balloted for and elected:—John Manby, as a Graduate; Frederick John Evans, Richard Ravenhill, and John Clutton, as Associates.

"A Mode of bending Discs of Silvered Plate Glass into concave or convex Mirrors by means of the pressure of the Atmosphere." By James Nasmyth.

Pneumatic Mirror.

The difficulty of obtaining large specula for telescopes, together with the disadvantages attending the weight, the brittleness, and liability to oxidation, of the speculum metal generally used, induced Mr. Nasmyth to turn his attention to the employment of silvered plate glass for telescopic purposes, as it possesses perfect truth of surface, is lighter than metal, is not liable to oxidation, and a greater quantity of light is reflected from it than from any metallic surface.

To give a concave or convex form to a disc of plate glass, a certain pressure must be made to act equally over the surface. This equal pressure is obtained on Mr. Nasmyth's plan, by taking advantage of the weight of the atmosphere.

A disc of silvered plate glass, 39 inches in diameter and $\frac{3}{16}$ths of an inch in thickness, is fitted and cemented into a shallow cast-iron dish, turned true on its face so as to render the chamber behind the glass perfectly air tight; by means of a tube communicating with this chamber, any portion of air can be withdrawn or injected.

To produce a concave mirror so slight a power is required, that on applying the mouth to the tube and exhausting the chamber, the weight of the atmosphere, which amounts in this case to 3558 lbs., acting with equal pressure over a surface of 1186 square inches, causes the glass to assume a concavity of nearly three-quarters of an inch, which, in a diameter of 39 inches, is far beyond what would ever be required for telescopic purposes. On re-admitting the air, the glass immediately recovers its plane surface, and on forcing in air with the power of the lungs, it assumes a degree of convexity nearly equal to its former concavity. The degree of concavity or convexity may be regulated to the greatest nicety, and it is proposed to render the degree of concavity constant by placing in the air-tight chamber a disc of iron turned to the required form, and allowing the pressure of the atmosphere to retain the glass in the form given to it by its close contact with the iron disc.

The curve naturally taken by the glass when under the pressure of the atmosphere is believed by Mr. Nasmyth to be the catenary, inasmuch as its section would be the same as that of a line suspended from each end, and loaded equally throughout its length.

Mr. Lowe did not feel well assured that the curve naturally taken by the "Pneumatic Mirror" was the catenarian, as the plate being set in a frame was supported all round its periphery, and resembled an arch resting on its abutments. He suggested the propriety of attempting to attain given curves by grinding the plate of different thicknesses in parts, so that the pressure of the atmosphere should affect it unequally.

Mr. Macneill was inclined to believe the curve assumed was the "Elastic Curve,"—the properties of which were examined by James Bernouilli, in the Memoirs of the Academy of Science, 1703.

March 17, 1840.

HENRY R. PALMER, V. P., in the Chair.

The following were balloted for and elected:—Theodore Budd and Thomas Steel, as Graduates; Geddes Pearce, William Lane, Thomas Jevons, and George Mills, as Associates.

"An Account of the Performances of the Locomotive Engines on the London and Birmingham Railway during the year 1839." By Edward Bury, M. Inst. C. E.

Locomotive Engines.

The engines used on the London and Birmingham Railway are all constructed on the same principle as to the main parts, the whole being upon four wheels, and only differing from each other in some of the minor details. The engines used for the conveyance of passengers have cylinders 12 inches diameter, with an 18-inch stroke; the driving wheels are 5 feet diameter, and the carrying wheels 4 feet diameter. The merchandize engines have cylinders 13 inches diameter, with an 18-inch stroke, and differ from the others in having all the wheels of 5 feet diameter and coupled together. The framing is of wrought iron, fixed inside the wheels for the greater convenience of connecting it with the boiler. The cylinders are attached to the frame by two strong wrought-iron bars passing beneath the lower semi-diameter, and secured by bolts to the ears cast on them. The cranks and fore-axles are also fixed to the frame. By this arrangement, any concussion is received directly by that part of the machine best calculated to bear it, and when the force of the engine is exerted in either pushing or drawing, it is done directly through the line of the framing, and thus any strain is diverted from the boiler or from those parts of the machine liable to be injured. There are only two bearings on the axles, and they are inside the wheels. Any tendency towards depression in the centre from the weight would be counteracted by the continual upward pressure, arising from blows received by the flanch of the wheels striking against the rails on curves, passing crossings, &c. The bushes which the axles run in are fitted into the frame in such a manner as to allow the springs to play vertically, but have flanches which prevent any tendency to lateral action beyond that necessary for the irregularities of the road, and they are of such a length as to enable them to hold up the engine in case of the breakage of one of the axles. It would appear that the breakage of the axles is a very rare occurrence, and that even when it has happened, the engines have performed the remainder of the journey and brought home the train with only a slight diminution of speed. The engines differ in weight according to the class they belong to. A passenger engine, with its coke and water in the fire-box and boiler, weighs 9 tons 13 cwts. 1 qr.

	Tons.	cwts.	qrs.
The fore end . .	3	19	1
The after end . .	5	17	2

A merchandize engine, with coke and water, weighs 11 tons 13 cwts. 1 qr.

	Tons.	cwts.	qrs.
The fore end . .	5	4	1
The after end . .	6	12	3

This form of engine was adopted by the author as early as the year 1829, when he constructed the "Liverpool," which was the original model engine with horizontal cylinders and cranked axles. It was set to work on the Liverpool and Manchester Railway in July, 1830. This form of engine has been invariably used on the London and Birmingham Railway since its opening.

The paper is accompanied by complete drawings of the engines, and tabular statements of their performances during the year 1839, showing the number of miles traversed by each engine, the weight conveyed, with the cost in detail of coke, oil, tools, wages, repairs, and general charges.

The performances of the engines extend over a distance of 700,000 miles, and a period of 12 months; and it appears that with the passenger engines—

For the first 6 months the average total cost of conveyance was . . $\frac{\cdot 352}{1000}$ of a penny per ton per mile.

For the second 6 months the average total cost was . . . . . $\frac{\cdot 380}{1000}$ ditto

While with the merchandize engines—

For the first 6 months the average total cost was . . . . . $\frac{\cdot 203}{1000}$ ditto

And for the second 6 months the average total cost was . . . . . $\frac{\cdot 227}{1000}$ ditto.

"Earth Falls at the Undercliff in the Isle of Wight." By William Rickman.

Earth Falls at the Undercliff.

The remarkable tract of coast called the "Undercliff" extends from the south point of the Isle of Wight, nine miles to the eastward. Its surface is distorted in form, somewhat resembling in miniature the volcanic features of Southern Italy; for although the latter has been formed by the action of fire, and the former by that of water, both have been moulded when in a state of partial fluidity. The soil is of a boggy nature, is intersected with numerous springs, and in it are imbedded in the utmost confusion detached masses of the weather-worn cliff rock, forming in places natural terraces on the face of the cliff, and inclining inwards at different angles towards the land.

A sectional view taken through the south point, bearing north to the summit of St. Catherine's Down, would present these features.

From the sea beach of iron sand, strewed with shingle and boulders, rises a cliff of 60 feet, and from it a rugged and irregular ascent of 320 feet in height, half a mile in extent, composed of vegetable soil, chalk, green sand-stone in masses and fragments, and of blue marle, the whole mingled indiscriminately and irrigated by numerous springs. Thus much constitutes the "Undercliff." Above it appears the perpendicular, serrated profile of the Upper Cliff, 260 feet in height, from which the surface of the Down proceeds with a slight descent for a quarter of a mile, and then gradually rises in the extent of half a mile to a vertical height of 200 feet, being the highest land in the island—780 feet above the level of the sea. The strata are nearly horizontal, with a slight dip to the north-east. They are the upper part of the secondary or supermedial order, and consist of chalk, chalk-stone, green sand-stone, blue marle, and iron or red sand.

This stratification would account for the subsidences of the Cliff which have occurred so repeatedly. The water collected by the extensive surface of the Down would percolate through the chalk and sand-stone beds until it reached the impervious blue marle, where it would accumulate until it finally escaped by oozing out over the edge of the stratum, carrying with it portions of the sandy subsoil; in this state it has the appearance of a slimy grit, consisting of particles of the sand-stone lubricated with clay; it is familiarly called "the blue slipper." A continuation of this infiltration for any length of time must end by undermining certain portions of the face of the Cliff, which, being unsupported beneath, detach themselves from the main rock and settle; the first settlement may not exceed a few inches, but a fissure having been formed the whole length behind the subsidence, the surface water pours into it, and continuing to moisten and undermine it, at length causes the slip to assume its present aspect. This soakage of water at the back of the mass may be supposed to sap its foundation at the rear and to give it the dip inwards, which is observed in all cases, and most evidently in such as are farthest advanced in their descent. A number of natural terraces are thus formed, and the process may be traced in every stage of its progress at different parts of the Cliff, as at Mirables, in the Pelham Walks, at Ventnor, and at the Luccombe landslip. These subsidences appear to have succeeded each other at long intervals of time, but there is no record of any so extensive as that which occurred in 1799, at which time upwards of 100 acres were set in motion. That the principal landslips took place prior to the Norman Conquest is proved by the existence of Bonchurch and St. Lawrence Chapel, which are supposed to have been built soon after the manor was surveyed for entry in Doomsday Book.

The President observed, that although papers of this kind did not appear to be exactly adapted for the meetings of the Institution of Civil Engineers, yet, as geology was so intimately connected with engineering, and as it was always essential to ascertain accurately the nature of the ground where works were to be executed, such communications became not only acceptable, but very valuable, to the profession.

Mr. Lowe had paid much attention to a similar formation at Hastings, and while he agreed to the general correctness of the observations, he did not think a sufficient reason had been assigned for such a mass of iron sand with its incumbent chalk being driven seaward. He would attribute the subsidences at the Undercliff to the action of water percolating through the fissures into the thin beds of clay interspersed with lignites, with which the iron sand abounded. This, when moistened, would ooze out and permit the chalk to crush it outwards, causing the subsidences so ably described by Mr. Rickman.

March 24, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—Charles Lanyon, as a Member; Henry Addams, Thomas Macdougal Smith, and Robert Richardson, as Graduates; Henry Heathorn and Ardaseer Cursetjee, as Associates.

"On the Manufacture of Flint Glass." By Apsley Pellatt, Assoc. Inst. C. E.

Flint Glass.

Flint glass, called by the French "cristal," from its resemblance to real crystal, is composed of silex (whence the English name), to which is added carbonate of potash and litharge, or red lead; to which latter material is owing, not only its great specific gravity, but its superior lustre, its ductility, and power of refraction.

It is necessary for optical purposes that flint glass should be perfectly free from striæ, otherwise the rays of light passing through it diverge and become distorted, and this defect is caused by the want of homogeneity in the melted mass, occasioned by the difficulty of perfectly fusing substances of such different density as the materials employed. The materials, being properly prepared, are thrown at intervals into a crucible of Stourbridge clay, which will hold about 1600 lbs. weight of glass when fused. The mouth of the crucible is then covered with a double stopper, but not luted, to permit the escape of the moisture remaining in the materials, as well as the carbonic acid gas and excess of oxygen. It requires from 50 to 60 hours application of a rapid, intense, and equal heat to effect the perfect fusion of the materials and to drive off the gas; during which time the unfused particles and excess of salts are skimmed off as they rise to the surface. The progress of fusion cannot be watched, nor can any mechanical means for blending the material during fusion be resorted to, lest the intensity of heat requisite for the production of a perfectly homogeneous glass should be diminished, the quality of the product being influenced by any inattention on the part of the fireman, as well as by the state of the atmosphere or of the wind. It has been ascertained, that there is a certain point or crisis of fusion at which the melted metal must be kept to insure a glass fit for optical purposes, and even when that point be attained, and the crucible shall furnish proper glass during several hours, should there be such diminution of heat as to require the furnace to be closed, the remainder of the metal in the crucible becomes curdy and full of striæ, and thus unfit for use. It is the same with the glass made for the flat bore tubes for thermometers, which are never annealed, because the smoke of the annealing furnace would render the interior of the bore unfit for the reception of the mercury. These tubes will only bear the heat of the blowpipe when they are made from a metal which has been produced under all the favourable circumstances before described. It is, therefore, to be inferred, that the most homogeneous and perfect flint glass can only be produced by exposure to an intense and equable degree of heat, and that any excess or diminution of that heat is injurious to its quality.

Flint Plate.

The English method of manufacturing the flint *plate* for optical purposes is thus described. About 7 lbs. weight of the metal is taken in a ladle of a conical shape from the pot at the proper point of fusion, and then blown into a hollow cylinder, cut open, and flattened into a sheet of glass of about 14 inches by 20, and varying in thickness from $\frac{3}{8}$ths to $\frac{1}{4}$th of an inch. This plate is afterwards annealed, and in this state goes into the hands of the optician, who cuts and grinds it into the requisite form. When a glass furnace is about to be put out, whole pots of metal are sometimes suffered to remain in it, and cool gradually. The crucibles being destroyed, pieces of glass may be cloven from the mass of metal, softened by heat, and made to assume the requisite form, and then ground. It is believed that the excellent glasses made by Frauenhoffer, and other manufacturers on the continent, are produced by some such means. On attempting to cut glass ware, it is easily perceived if it be sufficiently annealed; if not, the ware is put into tepid water, which is heated, and kept at the boiling point during several hours; it is then suffered to become gradually cold. This method is more efficacious than re-annealing by the ordinary means. A piece of unannealed barometer tube of 40 inches in length being heated and quickly cooled, contracted only $\frac{1}{16}$th of an inch, whereas a similar piece, annealed by the usual means, contracted nearly $\frac{1}{8}$th of an inch. Unannealed flint glass, being heated and suddenly cooled in water, exhibits the appearance of a mass of crystals; it is thence inferred that the process of annealing renders the glass more compact and solid; it thus becomes incapable of polarization.

Elasticity of Flint Glass.

Flint glass being remarkably elastic, has caused it to be used for chronometers. To prove its elasticity, a hollow ball of unannealed glass of 3 inches diameter, weighing about 16 ounces, was dropped, *when cold*, from a height of 7 feet upon a stone floor; it rebounded uninjured about $3\frac{1}{2}$ feet, but broke on falling to the ground after the rebound. Similar balls, both at a *bright* and a *low red heat,* were dropped from the same height, and both broke immediately without any rebound; thus demonstrating that its elasticity only exists while cold. Glass being sometimes deteriorated in the process of reheating, not only in colour, but in its faculty of welding, by the sulphur existing in the coal or coke used in the furnace, this is prevented by occasionally throwing about a quart of cold water on the fire; the explosive vapour thus raised carries off the sulphureous gas.

Annealing.

The process of annealing has the remarkable property of carrying off from the glass the reddish tint imparted to it by manganese; and in large masses, not only the reddish tint disappears, but the glass sometimes becomes green or blue, probably by the action of the sulphureous acid gas from the coke. The reddish tint will however return, and the greenish one disappear, should the annealed glass be afterwards heated or remelted. Should the pot crack during fusion, and the flame or smoke come in contact with the melted metal, a green tint and abundance of dense striæ will be the consequence. Such an accident can only be repaired, if the crack be accessible, by throwing cold water on the exuding metal, which thus becomes gradually cooled, and itself forms a lute, so as to enable the process of melting to be continued. Long experience has shown that the best fuel for melting glass in the furnaces is oven-burnt coke mixed with a small quantity of screened coal.

Mr. Pellatt illustrated the preceding paper by specimens of glass exhibiting peculiar effects of crystallization; among them were cylindrical solid pieces of flint glass, which, from being suddenly cooled by plunging them into water, had the interior entirely dislocated, and were merely held together by the exterior coating; portions of tubes showing the same effect; a portion of a vase of white glass dipped into blue glass of a greater density—in cooling, the interior white glass appeared to be crushed by the contraction of the exterior coating; a similar vase of white and blue glass of more equal density had cooled, and bore cutting without cracking; a mass of optical glass, exhibiting striæ, specks, and imperfections; which, together with the modes of manufacture, he explained.

In answer to several questions, Mr. Pellatt was not aware of any attempt having been made to cut the bulb of Prince Rupert's drops: he believed the peculiar property of the bursting of these drops or tears, on the end being broken, arose from a crack suddenly commencing and extending itself rapidly throughout the mass, causing the dislocation of the particles. Flint glass is seldom sufficiently fluid to make these drops; they are generally made from glass which does not contain lead.

Alluding to the use of plate glass in Nasmyth's Pneumatic Mirror, he observed that, owing to the absence of lead, plate glass was purer and more homogeneous than flint glass, and the equality of thickness produced by grinding and polishing enabled the curve caused by the pressure of the atmosphere to be very regular.

The use of coke as a fuel, by the regularity of its combustion, assists materially in producing good results, and prevents the injury which frequently arises from a difference in the heating powers of various coals: unfortunately, the form of the furnaces causes the greatest heat to be in the centre, thus acting most powerfully upon the backs of the pots, instead of being equally distributed around them, which would be more desirable and would insure better results.

Mr. Pellatt still continued to use nine parts of coke mingled with one part of small coal in preference to any other fuel. He had abandoned the use of gas coke, and now purchased small coal at a low price, which he converted into a moderately-hard coke, rather less dense than that used for smelting iron. In the north of England, a charge of coal generally remained in the oven during 48 hours; in London, only 36 hours; he made lighter charges and coked them in 24 hours. He still found the calorific effect of 8 or 9 lbs. of coke to be equal to that of 12 lbs. of coal; in his ovens, 20 cwt. of coal produced 14 cwt. of coke.

Mr. Parkes inquired, which was the best method of annealing tubes for water gauges on boilers? He generally used those prepared by Mr. Adie, of Liverpool, who annealed them by placing them in cold water and gradually raising the temperature to the boiling point, at which it was kept for 24 hours; yet, in spite of these precautions, which generally were successful, he had seen twelve of these tubes break in one day, while an apparently ill-made tube had lasted six weeks. He found thin tubes last longer than thick ones. He was in the habit of removing the stains of bog water from his boiler gauges by scouring them with emery; when reheated, they invariably broke; after many experiments, he tried the use of acid, which answered perfectly, and no tubes were subsequently broken.

Mr. Pellatt recommended boiling as a safe and good mode of annealing all kinds of glass; in the ordinary method of annealing, thick and thin ware is often subjected to the same process, and remains in the leer for the same period: this would account for the superior duration of the thin tubes. He attributed the fracture of the tubes to the tension of the exterior coating and the vibration caused by the process of cleaning: this effect was so well known that old tube could scarcely be sold, as it generally broke in cleaning.

Mr. Hawkins observed, that tubes almost invariably broke in merely removing dust from the inside, whether it was done by rubbing with a tight packing or by slightly wiping it out. In some experiments on the production of carbonic acid gas, he used glass tubes of $\frac{3}{4}$ of an inch internal diameter and $\frac{1}{4}$ of an inch thick: they bore a pressure of 100 atmospheres. Some wrought-iron tubes into which holes of $\frac{1}{4}$ of an inch diameter were drilled and pieces of glass inserted, bore a pressure of 600 atmospheres.

March 31, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—John Brannis Birch, Charles Denroche, John William Power, Henry Rawnsley, and George Dobson, as Graduates.

"On reclaiming Land from the Sea, with Plans illustrative of Works in Loughs Swilly and Foyle." By J. W. Bazalgette, Grad. Inst. C. E.

Reclaiming Land in Loughs Swilly and Foyle.

The art of reclaiming land from the sea has been practised from a very remote period. Among the instances best known to us are Romney Marsh, in Kent; the Foss Dyke, in Lincolnshire; and the coasts of Holland and Flanders. The extreme fertility consequent on such reclamations has caused many attempts to be made, and nearly all have been successful; but none presents a greater prospect of success than that about to be undertaken under the direction of Mr. Macneil on the borders of Loughs Swilly and Foyle, in the counties of Donegal and Derry.

Lough Foyle communicates with the Irish Channel by a narrow inlet, above which it spreads over a wide tract of land, and then, suddenly contracting, joins the river Foyle about four and a half miles below Londonderry, up to which city it is navigable for vessels of 500 or 600 tons burden. The rush of the tide through such a small inlet has carried with it great quantities of alluvial soil, which it has gradually deposited on the side of the lough, and thus formed a bank which extends four or five miles in length, and is only covered by the tide at high water. In order to reclaim this tract of valuable land, of about 25,000 acres, it is proposed to construct, somewhat below low water, an embankment or sea wall, of about fourteen miles in length. The tide never rises here above twelve feet, nor is there ever any swell in the lough to endanger the structure.

Lough Swilly is wider at the mouth which opens into the Western Ocean, and is consequently more subject to the effect of wind, than Lough Foyle. The highest tides rise about 18 feet. Several embankments are proposed, which will reclaim altogether about 2000 acres of land; a tract already reclaimed, which is considered to be of the best quality in the country, lets at £5. per acre. The measurements and soundings to ascertain the best position and requisite depths of the embankments were thus taken. A tide gauge was permanently fixed on which the range of high and low water was marked; a constant register was kept of the soundings, and the time at which they were made; these were afterwards reduced to the high or low water of any one tide. The distances were determined at the same time, by means of a pocket sextant from the boat, angles being taken between certain fixed objects on the shore, so that the exact situation of the soundings could be ascertained and laid down with great accuracy. The slopes of the faces of the embankments vary on the sea face from three or four to one, and two to one on the land side. Each has a culvert 4 feet diameter, with sluices and flood-gates, founded upon piling with tie beams, and the spaces filled with concrete, the whole being covered with planking. The gates are at the lowest level of spring tides, so as to allow of the greatest degree of drainage. The wing walls of squared rubble stone stretching on either side of the gates are founded also on a bed of concrete, 4 feet wide by 2 feet deep. These gates are to be used either to keep back the fresh water for the purposes of irrigation, or for scouring away the silt which would accumulate externally in front of them. A bed of puddle, 4 feet 6 inches wide at the bottom and 3 feet wide on the top, extends longitudinally throughout the embankments. The land water is carried away by a series of catchwater drains, which extend around the reclaimed lands at the level of high water, having sufficient fall to secure its drainage through the sluices. These drains are puddled, and have their internal faces covered with sods, at an inclination of two to one.

As there are many situations where stone is very scarce, and where timber abounds, the author has turned his attention to devising a plan of embanking applicable to such localities. It may be thus briefly described: The body of the embankment should be of clay, earth, gravel, and stones, dug from the surface and thrown up in a bank, with a slope suited to the force likely to act upon it. On the water side is placed a strong facing of fascines, 6 feet thick at the bottom and 4 feet thick at the top, embedded in the soil in an oblique direction, the dip being towards the land; they are securely fastened down by iron screws running at right angles through the whole height. The land face is covered with sods. In a country where wood abounds, this kind of embankment would be formed at a very cheap rate. In other situations, where the embankments would be subjected to greater strain, the thickness of the mass of fascines should be increased to 13 feet at the bottom and 4 feet at the top. In this case, at 4 feet from the front of the bottom of the slope should be placed a row of fender fascines, 3 feet wide by 2 feet high, bolted down, for the purpose not only of defending the face of the bank from the action of the sea, but for retaining all deposits left behind by it; by which means the embankment would in time acquire a natural face of soil, as is the case with some of the embankments in Holland. The average cost of this kind of embankment, including the sluices and the necessary bed of puddle in the centre, would be about £12. per running yard.

This paper is accompanied by seven plans of the proposed embankments and charts of the loughs.

"On the Use of Mica, as a Substitute for Glass, in the Windows of Workshops." By Joseph Glynn, F.R.S., M. Inst. C. E., &c.

Mica as a Substitute for Glass.

In the windows of the workshops at the Butterly Iron Works so much glass was broken by the chippings of iron, that a substitute was sought which should resist a moderate blow, and yet be translucent. A quantity of sheets of mica were procured from Calcutta, which, when fixed into the cast-iron window frames, were found to resist the blow of a chipping of iron driven off by the chisel with such force as would have shivered a pane of glass. Mica possesses both toughness and elasticity, and when a piece of iron does penetrate it, merely a hole is made large enough to allow the piece to pass, while the other parts remain uninjured. It is not quite so transparent as glass, but it is not so much less so as to be objectionable; but this circumstance is not important at Butterly, as, in consequence of the quantity of fluoric acid gas evolved from the fluate of lime used as a flux in the blast furnaces, the glass in the windows is speedily acted upon, and assumes the appearance of being ground. Mica is a little more expensive than common glass; but, as its duration promises to be much longer, it must be more economical; and if an extensive use of it could be induced, a more ready supply would be obtained—probably from Pennsylvania or from Russia, where it is commonly used for windows in farm-houses, and also on board ships of war, as it is less liable to be fractured by the concussion of the air during the discharge of heavy artillery. It can be procured of almost any dimensions necessary for ordinary purposes, as it has been found in Russia in masses of nearly 3 feet diameter. It is susceptible of very minute subdivision, as, according to Haüy, it may be divided into plates no thicker than one three-hundred-thousandth part of an inch.

"On a Specimen of White Cedar from Bathurst, New Brunswick," sent by Mr. Churchill.

White Cedar Railway Sleepers.

The specimen exhibited to the meeting was of the dimensions calculated for a railway sleeper, for which use it was proposed to introduce this timber, as it is stated to possess, in a very superior degree, the quality of durability in situations calculated to try its properties. It can be imported at about 3*s.* 9*d.* to 4*s.* per sleeper.

Mr. Hawkins observed, that he knew that species of timber well, having seen it extensively employed in the United States. It is an evergreen tree, and grows only in wet or boggy grounds, and is found most plentifully in New Jersey, Maryland, and Virginia. It attains the height of 70 to 80 feet, but is rarely more than 3 feet in diameter. The concentric circles in it are always perfectly distinct, and prove that the tree only arrives at its full growth after a long term of years—as many as 277 annular rings have been counted in a trunk 21 inches diameter, at 5 feet from the ground. The wood is light, soft, fine grained, and easily wrought. It has an aromatic odour, which it preserves as long as it is guarded from humidity. It resists alternations of dryness and moisture better than any other wood; and on this account is extensively used for shingles for roofing. They sell at Baltimore for 4 to 5 dollars per 1000. These shingles will last from 30 to 40 years. It is in great demand for household utensils, so much so that a distinct class of coopers are called cedar coopers. It is used for boat building on account of its great buoyancy. Cedar boards are sold at Philadelphia at 20 dollars per 1000 feet. White cedar rails, with red cedar posts, form the most durable kind of fence, being known to have lasted from 50 to 60 years. The rails are sold at 6 to 8 dollars per 100, and the posts at 12 or 15 cents each.

Mr. Brunel did not think it was a cheap or a strong wood. He had used it chiefly for covering locomotive boilers, as it resisted heat better than any other wood. When he purchased some there was but little in the market, and it was consequently dear.

Mr. Joseph Horne objected to its use for sleepers on account of its tendency to split so easily; but he had found it resist wet perfectly.

April 7, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—Thomas Hawksley, as a Member; William Pole and John Dickenson, as Associates.

"Account of a series of Experiments on Locomotive Engines, more particularly on the 'England,' the 'Columbia,' and the 'Atlantic,' manufactured by Mr. Norris, of Philadelphia." By Captain Moorsom, R. E., Assoc. Inst. C. E.

Trials of American Locomotive Engines.

The engines of which the author more especially treats were constructed by Mr. Norris, of Philadelphia, and sent by him to England, under an agreement to supply "locomotive engines of a higher power, greater durability, and less weight," than could be obtained in this country. They were to be subjected to fifteen trials within thirty days, and prove their capability of drawing "up a gradient of 1 in 330, a load of 100 tons gross weight at the speed of 20 miles per hour; and up a gradient of 1 in 180, a load of 100 tons gross weight at the speed of 14 miles per hour." The pressure of the steam in the boiler was stipulated by the Grand Junction Company (on whose railway the trials were made) not to exceed 60 lbs. per square inch.

The construction of these engines is very simple, and the work plain. The boiler is horizontal, and contains 78 copper tubes, 2 inches diameter and 8 feet long each, with an iron fire-box. The cylinders, 10½ inches diameter, are slightly inclined downwards, and so placed that the piston rods work outside the wheels, thus avoiding the necessity of cranked axles. The frame is supported by 6 wheels: the two driving wheels, of 4 feet diameter, are placed close before the fire-box; the other four wheels, of 30 inches diameter, are attached to a truck, which carries the front end of the boiler, and is connected with the frame by a centre-pin, on which it turns freely, allowing the truck to accommodate itself to the exterior rail of the curve, and with the assistance of the cone of the wheels to pass round with very little stress upon the rails.

	Tons.	cwts.
The weight of the engine, with the boiler and fire-box full, was	9	11¼
That of the tender, with 21 cwts. of coke and 520 gallons of water, was	6	4¼
Total weight . . .	15	15½
The engine, when empty, weighed	8 tons.	

The trials were made on the Grand Junction Railway in April and May, 1839, and were continued over the whole distance from Birmingham to Liverpool, except when stopping short at Warrington to take loads; and occasionally making double trips, so as to travel the total distance of 156 miles per day. Attention was more particularly paid to the speed when ascending the gradients, which rise at the rate of 1 in 330 (16 feet in a mile) or 1 in 177 (29 feet 4 inches per mile), and as the engines approached these gradients frequently either at an accelerated or a diminished speed, the observations were made at the points most remote from the cause of variation from uniform velocity. Some of the trials were made with such a number of empty waggons to make up the weight, that the train attained a length of nearly an eighth of a mile; this required some allowance, which was estimated at from one-eighth to one-ninth in addition to the actual weight of the empty waggons.

The extreme limit of working pressure of the steam in the boiler was 62 lbs. per square inch, except for a few minutes on one occasion, when it rose to 64 lbs. The usual pressure for the locomotive engine boilers on railways now generally at work is from 50 to 75 lbs. per square inch.

An analysis of the tabulated results of the several trips give these general results:—That on a plane of 1 in 330, with a load varying from 100 to 120 tons, the speed varied from 13$\frac{8}{10}$ miles to 22½ miles per hour; that on a plane of 1 in 177, with a load of 100 tons, the speed varied from $9\frac{8}{10}$ miles to $13\frac{8}{10}$ miles per hour.

From the analysis it appears, that allowing in five of the trials the stipulated amount of performance to have been made, and that in five other trials a doubt may exist, still in the remaining eleven trials the exact amount of duty demanded was *not* performed.

A comparison of the journeys *up* from Liverpool to Birmingham, with those *down* from Birmingham to Liverpool, gives rather a singular result. The aggregate rise of the gradients from Liverpool to Birmingham is about 620 feet, that from Birmingham to Liverpool is about 380 feet (exclusive in both cases of the Liverpool and Manchester Railway); the difference, therefore, up to Birmingham is about 240 feet. In 7 journeys of 596 miles *up* to Birmingham, the engine conveyed 682 tons gross, evaporated 12,705 gallons of water, and consumed 177 sacks of coke ($1\frac{1}{2}$ cwt. each). In 7 journeys of 596 miles *down* from Birmingham, the same engine conveyed 629 tons gross, evaporated 12,379 gallons of water, and consumed 177 sacks of coke. It would thus appear that the consumption of fuel was the same in both cases, and the only difference was the evaporation of 326 gallons of water more in the journey *up* than in the journey *down*, conveying nearly the same load both ways.

The author remarks, that in the early stage of his observations on the engine, he would have inferred that, from the mode of construction, it was not calculated for high speeds, such as are required for the mail trains; yet that he has often seen it travel with apparent ease at the speed of 30 miles per hour; and he thinks that, with some slight modification of the working parts, engines of this construction may be made to do any duty now required from locomotive engines; and, from the small quantity of repair required during the trials (only renewing the fire-bars, which were originally intended for burning wood, and putting nine stronger ferules in the tubes), he is of opinion, that the present construction is exceedingly well calculated for heavy loads—that it may be modified for attaining high speeds—and will prove a durable and economical machine.

Captain Moorsom, in reply to some questions from several members, stated, that although the American locomotive engines had not strictly complied with the stipulated conditions, yet he considered them good, serviceable engines, and it was the intention of the directors of the Birmingham and Gloucester Railway Company to have ten of them on their line. The price of the engine complete, including the import duty of 20 per cent., is from £1500. to £1600. One of the greatest advantages of the engines is the facility afforded by the truck for going round curves—the same engineers managing indiscriminately the ordinary six-wheeled engines, and the American ones are observed to go faster round the curves with the latter than with the former. Round a curve of 10 chains radius, they had gone at a speed of 20 miles per hour. They run also quite as well on a straight road. He had travelled on them between Whitmore and Crewe at the speed of from 30 to 40 miles per hour. They appeared less likely to be thrown off the rails than other engines, as in some instances they had run over the short pointers of the Grand Junction Railway—the engineer had merely felt a slight jar, but no accident had occurred. He attributed this to the truck adapting itself so readily to the rails. The coke used in the trials was the same as that in daily use on the Grand Junction Railway, and was of average quality. The mode of attaching the tender to the engine was peculiar, and he conceived it to be advantageous, as it threw a portion of the weight upon the engine and was an assistance in starting. The engines, as they are now constructed, will do well for all ordinary speeds; but if higher speeds are required, a greater expense must be incurred, and certain alterations must be made in them.

Mr. Bury conceived the chief peculiarity of the engine to consist in the end of the boiler being placed on the moveable truck, which certainly enabled it to adapt itself easily to any curve in the railway. The cylinders are in the same position as those in the first of Stephenson's engines, and the other parts are as nearly as possible identical with plain engines constructed in England. The pointers on the Grand Junction Railway are constructed and placed in such a manner as not to throw off a carriage which might run over them, and a four-wheeled engine would not have been thrown off by meeting a closed pointer. To enable him to form a correct comparative estimate of the work done by these engines, it should be shown what power was exerted at the wheels. This was a clear mode of arriving at a result and comparison with other engines.

Mr. Donkin remarked, that the flanches on the wheels appeared to be all that retained them on the rails, and that the truck turning on a centre-pin would allow considerable lateral friction, unless there was some mode of keeping the truck in a proper position when on a straight line of railway. If this kind of engine is superior to those generally in use in this country, it must be in some part of the construction which is not shown in the model or by the description. He inquired whether, in any of the four or six-wheeled English engines, any provision is made for changing the position of the axles, so as to allow of a divergence from parallelism when rounding curves?

Mr. Bury replied, that in the engines on the Leeds and Manchester Railway, although the axles were placed parallel to each other, a considerable allowance was made in the journals of one pair of the wheels, so as to facilitate the passage round curves.

The President observed, that the wheels being turned conically was of much assistance in passing curves, even although the axles were confined by the journals in a parallel position. He was aware that this threw an extra strain upon the curve rails, but that would only require more attention in securing them than on the straight line of railway.

Model of the Coal Field of the Forest of Dean.

Mr. Sopwith exhibited a model of a tract of 36 square miles of Gloucestershire, comprising the mining districts in the Forest of Dean. This model showed all the undulations of the surface, the towns, villages, and detached buildings, railways, coal and iron mines; and, separating vertically through the centre from north to south, and from east and west, exhibited the geological formation down through the coal measures to the old red sand-stone: the construction is such that, by lifting off horizontal layers, the extent and position of each bed of coal is shown, with the extent of the workings in the different collieries, and on each bed is marked the portion that can be worked by level and freed from water by natural drainage. This coal tract forms an elliptical basin; the longest diameter of which, from N. N. E. to S. S.W. is about 10 miles, and the shorter about 6 miles, ranging round Coleford as a centre. There are about 20 beds of coal of various thickness, containing together nearly 37 feet of clear coal. The carboniferous strata crop out regularly all round against the mountain lime-stone and old red sand-stone, and dip uniformly towards the centre of the basin. This could scarcely be shown clearly, even by an almost indefinite number of plans, which induced Mr. Sopwith to project the model, the method of constructing which he described to be by framing together in squares a given number of thin strips of wood, joining them by half lapping at the intersections; on these strips, the profiles of the sections were drawn, from measurements and borings. The compartments of these skeleton frames were then filled in with lime-tree wood, as being lightest and easiest to work, and carved out to the depth of the lines drawn on the strips; by these means a series of horizontal sections fitting into each other were obtained, and when painted of the proper colours, both on the surfaces and on the edges, produced the complete model which he exhibited. The cost of it was about £30. complete. It was constructed under Mr. Sopwith's direction, and from surveys made by him for the Government.

April 14, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—James C. Sherrard and George H. Phipps, as Members; and John Harris, as a Graduate.

"Description of the Steam Ship 'India,' with a table of the proportions of large Steam Ships." By Lieutenant E. N. Kendall, R.N., Assoc. Inst. C. E.

The Steam Ship "India."

This vessel was built at Greenock by Messrs. John Scott and Sons, and the engines were constructed by Messrs. Scott, Sinclair, and Co. To render her eligible as a packet ship between London and Calcutta, *via* the Cape of Good Hope, the timbers were lengthened so as to admit of the quarter deck and forecastle being raised 2 feet more than is usual; by which means a flush deck was formed along the whole length of the vessel, 200 feet by 29 feet, materially adding to the comfort and convenience of the passengers.

The long flat floor, with straight sides and fine ends, adopted in all the best of the Clyde-built ships, for the purpose of attaining a considerable speed with comparatively small power, and uniting with a light draft of water a good capacity for cargo or passengers, has been adhered to, although the established usage on the Clyde of making the length six times the beam has been somewhat exceeded, without impairing the speed, as the voyage from Greenock to London was made in 86 hours, against a strong head wind during a considerable portion of the time.

The rigging is fitted so as to combine lightness with strength, and the facility of making every thing "snug" when steaming against the wind; the spars being so proportioned as to carry a large spread of canvass when running down the trade winds. There are several improvements in the rigging. Two of them are particularly mentioned. 1st. The employment of iron sockets, into which the shrouds, having been tapered, parcelled, and served, are inserted and firmly rivetted. Instead of passing over the mast-head, they are attached by shackles to a series of holes along the edge of a strong wrought-iron plate or cap which surrounds the mast. This is more secure than the ordinary fastening, as it prevents all chafing or injury from the wet, besides being more compact, and allows any repairs to be more easily effected. 2nd. The mode of fitting the fore-yard for coming down readily in bad weather. The truss bow is made sufficiently large to admit of the heel of the fore-top-mast passing readily through it, and has on its fore-end an eye through which passes an iron bolt, 5 feet long, which is held in its position by a chain passing round the mast-head; to the lower end of the bolt is attached a chain, which passes through a swivel eye on the yard, and is drawn tight by a screw traversing one of the deck-beams. When the yard is hoisted up, it slides along the chain jackstay, which prevents it from swaying about until it reaches the bolt which enters the swivel eye, and when it is close up, the yard is slung by two short chains shackled on to the mast-head chains. The operations of striking the yard and top-mast may be thus accomplished simultaneously in a few minutes in the worst weather, or they may be replaced in the same short period.

The engines have most of the acknowledged improvements, and are fitted with "Hall's Condensers" in such a manner that they can work with them or with the ordinary condensers. The cylinders are 62 inches in diameter, with 5 feet 9 inches stroke. The diameter of the paddle wheels is 26 feet; the length of the floats is 8 feet, divided into two parts in the depth, and fixed one before and the other behind the arms. There is an apparatus for cutting off the steam at any portion of the stroke. The boilers are of a peculiar construction, combining vertical flues with a series of horizontal fire tubes, exposing a very considerable surface so as to be worked by slow combustion of the fuel from two sets of fire-places over each other; by throwing on the coals alternately, the gas evolved from the fresh fuel is ignited in its passage over the other fire-places. A considerable economy has been effected by these means.

The paper is accompanied by a drawing of the improvements in the rigging, with plans of the vessel and engines, and a tabular statement of the proportions and scantling of a number of other large steam ships.

"Description of a Dynamometer, or an Instrument for measuring the Friction on Roads, Railways, Canals, &c." By Henry Carr, Grad. Inst. C. E.

Dynamometer.

The object of Mr. Carr's modification of the dynamometer is to obviate the irregularity of the common indicator arm, caused by the jerking motion of the tractive power or any inequality of resistance. The instrument consists of a cylinder half filled with mercury, and containing a piston connected with the spring of the dynamometer, so as to be lowered or raised as the tractive power is increased or diminished. Two tubes of glass, connected by a passage with a regulating valve, stand in front of the cylinder, one of them communicating freely with it, and in this tube the mercury is raised or lowered proportionally to the power applied; while in the other, an average of the variations is obtained as the facility of communication between the tubes is increased or diminished by the opening or closing of the stop-valve. The instrument must be graduated by actual experiment, and the results of the average power may be read off from the scales placed behind the tubes. The paper is illustrated by a detailed drawing of the machine.

"An Account of a proposed Suspension Bridge over the Haslar Lake at Portsmouth." By Andrew Burn, Jun., Grad. Inst. C. E.

Suspension Bridge with Cast-iron Chains.

The usual calculation for the maximum load on each superficial foot of the platforms of suspension bridges is 70 lbs.; but, as in the event of a crowd of persons assembling the pressure may increase to nearly 100 lbs. per foot, and by the passage of soldiers marching in regular time the strain may be greatly augmented, the projector assumed 200 lbs. per superficial foot as the amount of load to which the platform might be subjected. The peculiar feature of this bridge is the substitution of cast-iron chains for the wrought-iron ones generally used. This deviation from the usual practice is adopted as a measure of economy, and with a view of increasing their stability and durability, cast iron being much less influenced by atmospheric action than wrought iron. Cast-iron beams, when well proportioned, will bear a very considerable tensile strain. As these chains would be proved beyond the weight they are intended to bear, no doubt is entertained by the author of their security. The platform, which is formed of transverse iron girders carrying cast-iron plates $\frac{3}{4}$ of an inch thick, with dovetails falling into holes cast in the girders, is suspended by wrought-iron rods $1\frac{1}{2}$ inch square from two lines of chain only, as the strain is more easily brought to bear on them than on a greater number of chains. They are trussed laterally to prevent oscillation, and the balustrade is so constructed as to prevent the undulation so prejudicial to suspension bridges generally. To insure a perfect bearing, each pair of links of the chains are in manufacturing cramped together, and the holes bored out to receive the pins which are turned to fit them accurately; they are of a larger size than usual, being 4 inches diameter, and a less number are employed. The piers on which the chains pass are of cast iron, 33 feet high above the level of the roadway.

	Feet.
The extreme length of the bridge is . . .	632
The breadth of the roadway	17½
The clear waterway between the piers . .	300
The clear headway of the platform above the high water line	18½
Ditto ditto above low water line .	33

The tension on the chains is calculated as equal to 991.4143 tons. To sustain this tension, the section of the chains is 256 square inches, and taking 7 tons per square inch as the elastic limit of cast iron, the resistance of the chains will equal 1792 tons, leaving a surplus of 800.6 tons after the calculated strain has been deducted from the real strength of the chains. Three elaborate detailed drawings accompany this paper.

Mr. Smith, of Deenston, explained a new system of Lockage for Canals proposed by him, a model of which he presented to the Institution.

New System of Lockage for Canals.

To avoid the present expensive construction of locks and their waste of water, the author proposes to divide the canal into a series of basins, the water levels of which should be from 12 to 18 inches above each other. The extremity of each basin is so contracted as to permit only the free passage of a boat; in this is placed a single gate, hinged to a sill across the bottom, the head pointing at a given angle against the stream, and the lateral faces pressing against rabbets in the masonry. The gate is to be constructed of buoyant materials, or made hollow so as to float and be held up by the pressure of the water in the higher level; on the top is a roller to facilitate the passage of the boats. When a boat is required to pass from a higher to a lower level, the bow end, which must be armed with an inclined projection, depresses the gate as much as the depth of the immersion of the boat, and as much water escapes as can pass between its sides and the walls of the contracted part of the basin. The same action takes place in ascending. except that a certain amount of power must be expended to enable the boat to surmount the difference of level between the basins. The quantity of water wasted by each boat would be in proportion to its immersion and the speed at which it passed over the gate. In case of different sized boats passing along the same canal, it is proposed to have a small gate forming part of the main gate, so as to avoid the loss of water which would ensue from the whole width being open for the passage of a small boat.

This system has only been tried by models; but it is proposed to make an essay on an extensive canal next summer, when the results will be communicated to the Institution.

May 5, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected :—Angier March Perkins, St. George Burke, and Beriah Botfield, as Associates.

"Description of the Engines on board the Iron Steam Tug, the Alice." By J. Patrick, Inst. C. E.

The Steam Boat, the "Alice."

The speed of this boat having far exceeded the constructor's expectations, induced the author to send a description of her proportions, and of the construction of the engines. The chief peculiarity in the engines is their being placed in the centre of the vessel, with the two cylinders in a line with the keel, and placed at an angle of 45°, inclining inwards towards the paddle shaft, to which the motion is communicated direct (without the use of side beams) by long connecting rods attached to the cross heads, which are placed at the lower ends of the cylinders, instead of being on the top as in the usual manner; the connecting rods are thus enabled to be three times instead of twice the length of the stroke, as is usually the case. The framing is entirely of wrought iron on the tension principle, and appears to resist the tendency to vibration better than cast-iron framing. For the two cylinders of 31 inches diameter, there is only one air pump of 22½ inches diameter, with 19½ inches length of stroke, instead of the usual complement of two air pumps, 18 inches diameter each; this is found to be sufficient, as a vacuum of 13¾ lbs. per square inch is maintained. One of the advantages proposed by this mode of construction is the reduction of weight; these engines only weighing 9 cwt. per horse power. The small space occupied leaving more room for passengers, they are particularly adapted for river navigation, where the breadth of beam must be limited. The simplicity of their construction renders them less liable to expensive repairs.

The principal proportions of the Alice are—

	feet	inches
Length between perpendiculars . .	95	
Breadth of beam	20	
Draft of water	4	6
Diameter of wheel	14	
Size of engines	two 30 horse power	
Diameter of cylinder	31 inches	
Length of stroke	3 ft. 3 in.	

The engines were constructed by Messrs. Davenport and Grindrod, of Liverpool. Drawings of the boat and engines accompany this communication.

"Description of an Apparatus for preventing the Explosion of Steam Boilers." By Robert M'Ewen.

Apparatus for preventing the explosion of Steam Boilers.

The frequent explosions of steam boilers, caused in many instances by the steam being confined until it acquires a density greater than the boiler can resist, induced the author to invent a simple, self-acting apparatus, intended to warn the engineer whenever the pressure exceeded the proper degree of safety.

The apparatus under consideration is constructed on the principle that steam, in proportion to its density, will support a column of water, or mercury, of a given height, and that any fluid will find the same level in two or more vessels, provided there be a free communication between them. It may be called a mercurial safety valve, and consists of a cylinder, within which are two cups, with two pipes dipping into them of a length proportioned to the pressure of the steam; these pipes are connected at the top with two valves on one spindle, so arranged, as that when one is open the other must be closed. On the top is a waste steam pipe open to the atmosphere. One pipe being filled with mercury, and the valve connected with it being open, the mercury remains stationary until the pressure of the steam exceeds its proper point. It will then be blown out and fall into the empty cup, allowing the steam to escape by the waste pipe, and giving warning to the engineer by its noise. When the pressure is again reduced to its proper point the valve is reversed, and the mercury will, on the next occasion of an increase of pressure, be blown back again, still giving warning on either side.

Plans and sections of this apparatus accompanied the paper.

"On setting out Railway Curves." By Charles Bourns, Assoc. Inst. C. E.

Setting out Railway Curves.

Mr. Bourns having been engaged in setting out the Taff Vale Railway through a country presenting circumstances of more than ordinary difficulty, which rendered it necessary to vary the radii and the flexure of the curves frequently, his attention was particularly directed to the subject; and he has treated it in this paper clearly and successfully, demonstrating the several cases geometrically, and generally in a plain and satisfactory manner. He calls attention to the inaccuracy of applying a square to the setting out of segmental curves, particularly those of short radii, and recommends an offset staff as theoretically correct and practically much more convenient. The general rule to find the offset is — "Divide the number of inches in the chain used by the number of such chains in the radius of the required curve, the quotient is the offset in inches." The paper is accompanied by a table of offsets for curves of different radii; which the author found extremely convenient for use in the field.

The paper being altogether mathematical is not adapted for publication in abstract; but it will be given at length, with examples and diagrams, in the Transactions of the Institution.

"Description of an Instrument for describing the Profile of Roads." By Henry Carr, Grad. Inst. C. E.

Instrument for describing the Profile of Roads.

The object of the author was the construction of a machine, which, being drawn along any road of moderately even surface, should describe the section of the line over which it passed. It is evident, that if a pendulum be suspended from a frame standing perpendicularly when the machine rests on a horizontal plane, on passing over a plane inclined at any angle with the horizon, the pendulum must form the same angle with the frame, the tangent of which angle in terms of the radius will be the rise or fall of the plane. The duration of the tangent will be determined by the paper on which the section is drawn being made to traverse at a speed proportionate to the distance passed over; and the extent, by the difference of the speeds of a nut and screw which are made to revolve in the same direction—the nut turning at a constant velocity, and the screw at a speed differing from that of the nut in proportion to the tangent, slower or faster as the tangent is *plus* or *minus*, raising or lowering the nut according to the deviation of the plane from the horizontal line.

The machinery is set in motion by the wheels of the carriage, and a series of wheels and pinions of given diameters cause the ground line and datum line to be drawn simultaneously by two pencils on a paper which gradually unfolds itself from one drum, and is transferred to another at the rate of 16 inches per mile passed over, or on a scale of 5 chains to the inch. A profile of a line of country may thus be obtained with sufficient accuracy for a preliminary survey.

A comprehensive perspective drawing accompanies the paper and explains the construction of the machine.

May 12, 1840.

The PRESIDENT in the Chair.

"Photography, as applicable to Engineering." By Alexander Gordon, M. Inst. C. E.

Photography.

The object of the author in this paper is to direct general attention to the advantages which may be expected to result to the profession of the Civil Engineer from the discoveries of Mons. Daguerre and others, in enabling copies of drawings, or views of buildings, works, or even of machinery when not in motion, to be taken with perfect accuracy in a very short space of time and with comparatively small expense. This system of copying not only the outline, but the tints of light and shade, united with accurate linear perspective, he contends may be easily adapted to the purpose of the engineer, as well as to all those professions in which the art of drawing is used. The photographic apparatus has already been employed to bring before us exact copies of the most interesting monuments of antiquity, the French antiquarians and artists having found it more easy and correct to Daguerréotype the Egyptian monuments and decipher the hieroglyphics at their leisure, than to labour over the originals.

Photogeny.

The subject is divided into two branches: the first being the art of copying drawings and plans by the transmission and absorption of light by prepared paper. The drawing to be copied is placed between two pieces of plate glass, held down in close contact with a sheet of photogenic paper, prepared by being washed over on both sides with a neutral solution of nitrate of silver of a specific gravity of 1.066, and afterwards with a solution of common salt and water (1 lb. of salt to 25 pints of water). The paper thus prepared must be dried and kept in the dark, on account of its peculiar delicacy. The rays of the sun are then permitted to pass through the white portions of the drawing or print, while they are interrupted by the black lines, and more or less by the tinted portions. The rays of light thus act upon the prepared paper, and produce in a few minutes a reversed copy, reproducing the lights of the original in shadows; this can be remedied by taking a second copy from the first, and thus the shadows are restored to their original positions. To destroy the sensitiveness of the prepared paper and preserve the copy, it is soaked in pure water, which carries off the excess of nitrate of silver, then covered with a solution of hypo-sulphite of soda of a specific gravity of 1.055, and again washed in pure water, so that when dried it is permanently fixed. It is evident that a copy thus obtained must be exactly like the original, and the value of such a process may be readily estimated by engineers.

Daguerréotype.

The second branch, which is named "Daguerréotype," after the distinguished artist who brought it to its present state of perfection, is of a much higher order. This is the art of fixing and preserving on the surface of a polished silvered plate the images collected in the focal plane of a camera obscura.

The process is rather complicated, but may be thus briefly described. The surface of the silvered plate being cleaned and polished very perfectly by means of finely levigated pumice stone, olive oil, and cotton, is rubbed lightly over with diluted nitric acid, in the proportion of 1 pint of acid to 16 pints of distilled water; it is then subjected to the heat of charcoal or a spirit lamp until a firm white coating is formed all over the surface of the silver. The plate is then suddenly cooled. This process is repeated three times. It is placed in a dark chamber with the face or silver surface downwards, where it is acted upon by the spontaneous evaporation of iodine; this condenses upon the silver, and produces a fine gold-coloured surface, extremely sensitive to the impressions of light. It is then placed in a camera obscura, the light having been until then perfectly excluded from it. It there receives the impression of any images brought within the focal plane; and by subsequently exposing it in a dark, close chamber, with its silver surface downwards, to the fumes of heated mercury, the images are rendered visible; to fix the images so received, the iodine is removed by dipping the plate in pure water, and then washing it either with a weak solution of hypo-sulphite of soda or a saturated solution of common salt, and finally dipping it in distilled water and drying it. It should then be framed and glazed to preserve it from external injury, and the picture will remain unchanged.

Attempts have been made to use this process for preparing the plates for engravers, as much time and cost would thereby be saved, but hitherto it has not been done to any extent.

The author presses upon the Institution the applicability of these processes to engineering uses, and quotes the remark of Mons. Arago—"That photographic delineations having been subjected during their formation to the rules of geometry, we may be enabled by the aid of a few simple data to ascertain the exact dimensions of the most elevated parts of the most inaccessible edifices."

Mr. Cooper, Senior, introduced the subject of photography by explaining, and illustrating by instruments and diagrams, the principles of the division and dispersion of the rays of light, according to the Newtonian theory, as well as the most recent researches into the subject. He described the chemical properties of light—its affinity for certain combinations, such as chloride of silver—its heating powers—the different effects of the rays on vegetation—and the application of these known principles to photography. He then explained the chemical properties of the chloride of silver, iodine, and other substances used in the process. In alluding to the probable uses of the Daguerréotype, he observed that the process might be employed to make drawings of machinery, as graduated scales might be fixed to certain parts of the objects, and they would be copied in their relative proportions to the machine.

Mr. Cooper, Junior, illustrated Mr. Gordon's communication by explaining the photographic apparatus, and the process of obtaining a specimen of Daguerréotype by means of the oxy-hydrogen light. He described, among other points, the difficulty of obtaining pure silver upon the copper plates, as, for the advantage in rolling, the manufacturer will introduce an alloy of ½ to 1½ per cent. On this account, acid is used so repeatedly in cleaning the plates, that any particles of copper which have been rolled into the surface may be carried off. He explained his improvement to the iodine box, which consists in spreading the iodine all over the bottom of a tray lined with glass, and covering it with a piece of card-board, which becomes saturated with the fumes of the iodine, and on the silvered plate being placed over it, acts equally over its surface, instead of partially, as in the old system of placing the iodine in a mass in the centre of the tray. He had found this to be a great improvement. The shortest time in which he had obtained a photographic picture in England was 11 minutes; while, during a gloomy day in November, it took an hour and a half to procure a moderately good one.

"An Universal Screw-Jack." By George England.

Universal Screw-Jack.

This machine, a model of which was presented to the Institution, is intended for raising heavy weights and moving them in any required direction; the vertical motion is similar to that of a common screw-lifting jack, and the lateral motion is communicated by a ratchet lever to a horizontal screw, working in bearings on a strong cast-iron bed with planed surfaces through a double nut attached to the base of the jack. The jack has been found useful for erecting heavy pieces of machinery, and for replacing railway carriages and locomotives on the rails when they have been accidentally thrown off.

"Description of a Traversing Screw-Jack." By W. J. Curtis.

Railway Screw-Jack.

The screw-jack is attached to a plank with a rack in it, and slides in a groove in another plank which is placed beneath it, across the railway; in the lower plank is a rack, by means of which and a hooked lever, the jack, with the engine or any other weight resting upon it, is drawn easily across the rails and lowered to its proper position. By this apparatus, engines and carriages of considerable weight have been replaced on a railway by two men in a very short space of time.

A model of the machine was presented to the Institution.

May 19, 1840.

The **PRESIDENT** in the Chair.

Peter Bruff was balloted for and elected an Associate.

"Description of a new Gas Regulator." By James Milne.

Gas Regulator.

The object of this instrument (which the inventor exhibited in action, and presented to the Institution) is to regulate the supply of gas to burners, so that any variation in the pressure, arising from extinguishing the adjacent lights along the line of the street main, or in the different floors of manufactories, shall not affect those lights which are supplied through the regulator.

The regulator consists of a cylindrical outer case, to which is affixed a water gauge to show the pressure; to the top is attached an inner cylinder, open at the lower end and reaching nearly to the bottom of the outer case; the gas is introduced from beneath by a tube in the centre, terminating in a conical valve at the top: the male part of the valve is fixed by three arms to the top of a float, which moves freely in the space between the inner cylinder and the centre tube; the areas between the outer case and the inner cylinder, and between the inner cylinder and the centre tube, being alike, the pressure of the gas acts upon the water within the inner cylinder, and causes it to rise in the outer case just as much as it is depressed in the inner space. This depression carries down the float with the male part of the valve attached to it, and thus diminishes the aperture of the supply pipe, until the pressure is relieved by other burners being lighted, and enables the supply of gas to be in proportion to the demand. The pressure may be regulated at will by increasing or diminishing the quantity of water in the cylinders, and it is shown correctly by the graduated glass gauge. This apparatus has been found, in an experience of two years, to effect a saving of about 20 per cent., independent of its ensuring a perfect equality to all the burners in action. Drawings of the instrument accompanied this communication.

Mr. Lowe believed the "gas regulator" to be an efficient instrument. It was of the utmost importance that the light from gas should be steady and equal, as the nerves of the eye were more injured by an unsteady than by an intense light. In large establishments, the greatest care would scarcely prevent constant variation in the lights, so that an efficient means of producing regularity must be valuable.

"On the Properties and Chemical Constitution of Coal, with Remarks on the Methods of increasing its Calorific Effect, and preventing the Loss which occurs during its Combustion." By Charles Hood, F. R. A. S., &c.

The properties and chemical constitution of coal.

It appears that, previous even to the invasion of the Romans, coal was used as a fuel in Great Britain; but such was the prejudice against it, that wood was the fuel generally in use among the higher classes until the eighteenth century, when the supply of it diminished so considerably as to render necessary the substitution of coal; and from that time the increase in its consumption has been immense.

Previously to the seventeenth century, the smelting of iron and all other metals was performed by charcoal; but the attempts of Sturtevant and Ravenson in 1612–13 and of Dudley in 1619 to introduce the use of coal or coke in blast furnaces having proved the possibility of success, the progress of the innovation, though slow, was certain, and led to the transfer of the iron works from many of the original positions in the midst of forests to the coal districts where they are now placed.

The author considers his subject under three heads:—1st, The chemical character and composition of coal; 2dly, Its properties as a combustible; and 3dly, The nature and application of its various gaseous products.

The chemical character of coal.

1st. The opinion that coal is a compound of carbon and bitumen has been objected to by some chemists, on the ground that by no process hitherto pursued in analyses has it been possible to resolve it entirely into these two substances: even at a low temperature a quantity of gaseous matter is thrown off, and at an elevated degree of heat an evident decomposition of the bitumen takes place. Even anthracite contains a small portion of volatile matter, its component parts being carbon, oxygen, hydrogen, and nitrogen; the hydrogen being either combined with the oxygen to form water, or with a small portion of carbon to form carburetted hydrogen, which exists in a gaseous state in the pores of the coal. In bituminous coal, the hydrogen is combined with a larger proportion of oxygen and nitrogen; the mechanical difference being, that the bituminous and free-burning coals (more particularly) melt by heat when the bitumen reaches the boiling point, whereas anthracite is not fusible, nor will it change its form, until it is exposed to a much higher degree of temperature.

Two tables of the analyses of different coals are given from the authorities of Mushet, Thomson, Vanuxem, Daniells, Ure, and Reynault; No. 1 showing the proportions of carbon, ashes, and volatile matter, with the specific gravity of the coal and of the coke; and No. 2 showing the proportions of carbon, hydrogen, azote, and oxygen. These tables show that the largest quantity of carbon (92.87) is contained in the Kilkenny anthracite, and the least quantity (64.72) in Cannel coal; and that the nature of the volatile matter greatly affects the quantity of coke—the aggregate quantity of the gaseous products of coking, splint, and cherry coal, being very nearly similar; while the quantity of coke obtained from these different species varies more than 45 per cent.

The author then points out the continual presence of azote, which quits the base with the greatest difficulty; and also the affinity of sulphur, not only for the coal, but for the coke, as it is rarely found to have been completely expelled even from the most perfectly made coke; the only coal found to be even partially free from it being anthracite, in some species of which no traces of its presence are found.

The combustion of coal.

2dly. The application of coal as a fuel depends on the chemical change which it undergoes in uniting by the agency of heat with some body for which it possesses a powerful affinity. In all ordinary cases this effect is produced by its union with oxygen. When coal is entirely consumed, the carbon is wholly converted into carbonic acid gas and carbonic oxide, and the hydrogen into water in a state of vapour. The atmosphere supplies the necessary oxygen for this purpose; and in this state the products of the combination are nearly or quite invisible, both of them being almost colourless fluids: if, therefore, any smoke be visible, it is the result of imperfect combustion. Some calculations are given to ascertain the amount of loss that is sustained when the smoke escapes unconsumed; from which it appears, that with bituminous coal about 37 or 38 per cent. more heat is produced when the smoke is consumed than when it escapes freely. Many modes of consuming smoke have been attempted; those which appear to have been attended with the greatest success are—1st. Causing the smoke from the fresh coals to pass through or over that portion of the fuel which is more perfectly ignited; 2dly. Supplying heated air to the top of the fuel, as well as admitting cold air through the ash-pit in the usual manner; and 3dly, Throwing a jet of steam into the furnace or into the chimney. The various modes of carrying into effect these plans are briefly alluded to; from them a few may be selected. Robertson's plan was to use inclined furnace bars, where the fresh coals were placed close to the fire-door, and being there partially carbonized, gave out the gas which in passing over the mass of incandescent fuel was ignited, and became active flame, thus economizing fuel and preventing smoke. In this and similar cases, by the slow distillation of the coal, a gas is produced, which not only inflames at a lower temperature than the dense olefiant gas produced by rapid distillation, but which only requires for its combustion a quantity of oxygen, never exceeding double its own volume, or ten times its bulk of atmospheric air, while olefiant gas requires three times its own volume of oxygen, or fifteen times its bulk of atmospheric air. The elimination of a gas which burns with so small a portion of oxygen is, therefore, the principal cause of the non-production of smoke in furnaces of this description. The second mode of consuming smoke is founded on the necessity which exists for a large supply of air being requisite to inflame the gases given off from coal by a rapid and intense heat; and this is accomplished by introducing a quantity of heated air above the burning fuel. When a quantity of fuel is thrown into a furnace, the increased thickness of the mass opposes additional resistance to the passage of air through the bars; the temperature of the furnace is lowered, and an increased volume of gas is at the same time given out. If at this moment a quantity of air, heated to the temperature of the gas, be admitted, the gas immediately inflames, and that which would have produced a dense black smoke passes off in the invisible state of carbonic acid gas and vapour of water. Different gases require different degrees of heat to inflame them; and this explains the easy combustibility of the volatile products of coal when the heat is so managed as to produce those gases which inflame at the lowest temperature. A larger quantity of air is required at the time that the coal is first thrown on, than at a subsequent period; therefore, when economy is studied, the supply of air should be gradually diminished as the mass approaches an incandescent state. The use of heated air has produced most important results in the manufacture of iron with bituminous coal, and also with anthracite; the latter fuel having been almost neglected until the recent application of this principle of employing heated air to promote its combustion, although it is known to be capable of producing perhaps a more intense heat than any other carbonaceous fuel. The rationale of the third plan, of consuming smoke by injecting a jet of steam into the fire or the chimney, is less obvious than the others. In 1805, Mr. Davies Gilbert observed, that whenever the waste steam of one of Trevithick's engines was permitted to escape into the chimney, the smoke from the coal was rendered invisible. Subsequent experiments confirmed this fact; and it was supposed, that the steam being decomposed furnished oxygen to support combustion. The author combats this opinion, and accounts for the effect by the increased draught of the furnace caused by the jet of steam into the chimney, by which means a larger portion of air is brought into contact with the burning fuel; thus supplying the previous deficiency of oxygen to the fire, and promoting the combustion. As steam is only about half the weight of air at a like temperature, and the power of all gaseous fluids to ascend is "*inversely* as the square roots of their specific gravities," the velocity of its escape by the chimney, compared with common air of the same temperature, is about as 1·4 to 1; therefore the compound mixture of steam, air, and carbonic acid gas, will escape with a considerably increased velocity, and more air must consequently enter the furnace. It appears that about 10 per cent. of the total quantity of steam generated is necessary to effect the combustion of the smoke by this means; therefore, unless the waste steam only be used, the saving of the fuel must be reduced by this amount. Brief mention is made of the experiments of Messrs. Apsley Pellatt, Parkes, and the Chevalier de Pambour, proving that a given quantity of oven coke will produce as much heat as the coal from which it was produced; and of the various kinds of artificial fuels which have been invented, especially that composed of resin and peat coke, of which the author remarks that its combustion probably produces a mechanical effect, as the hydrogen is converted into water in a state of vapour, which escapes through the chimney with a great velocity, and consequently a large quantity of air is drawn into the furnace, and a more perfect combustion of the fuel is the result. In the same manner he accounts for the necessity which exists for having the openings between the bars wider in a furnace in which coke is burned than in one used for coal. In opposition to the general opinion, he considers that less air is required for the consumption of coke than for coal; the carbon only requiring 2½ times its weight of oxygen for its combustion, while the hydrogen contained in coal requires 8 times its weight of oxygen: and the only reason that the openings between the bars are required to be wider in the former than in the latter case, is in consequence of the draught being so much slower during the combustion of coke.

The application of the volatile products of coal.

3dly. "On the nature and application of the volatile products of coal." In treating this portion of the subject—many of the observations on which have been necessarily anticipated in the preceding sections—the author traces the application of carburetted hydrogen gas to the purposes of artificial illumination from the year 1798, when its first successful application was made by Murdock at Soho: he then proceeds to Dr. Henry's investigations of the phenomena of its production and combustion; the variation of the intensity of light obtained from carburetted hydrogen, due to the proportion of carbon contained in it; the difference in the gas obtained from different qualities of coal; the superiority of the illuminating power of the gas from Cannel coal; and the still greater power of that produced from the decomposition of oil, which is 2 to 2½ times greater than that of coal gas. He then mentions the other products of coal by distillation, such as ammoniacal liquor, carbonic acid and oxide, sulphuretted hydrogen, tar, essential oil, naptha, petroleum, asphaltum, and other substances. The paper concludes by pointing out the advantages which would result from the production of such gas as is usually given out at the beginning of the distillation of coal, as it contains 2 volumes of gaseous carbon united with 2 volumes of hydrogen, and its illuminating power is consequently more than double that of ordinary coal gas.

Mr. Parkes observed, that the quantities of air required for the combustion of different fuels as determined in the laboratory and on the large scale of practice, were frequently very different. It might be quite correct that a given weight of coal would require more air for its perfect combustion than the same weight of coke. There was great difficulty in ascertaining the fact practically, under steam-boilers, as the gases given out by the coal must have air supplied to them distinct from that which passed through the grate to ensure their perfect ignition, and many circumstances prevented the consumption of air from being exactly measured. Generally, he had found it necessary to use wider spaces between the grate bars for coke than for coal. In some late experiments very carefully made on a boiler invented by Mr. A. M. Perkins, equal weights of coal and coke required the same time for their destruction on the same grate, the apertures of the damper and ash-pit door, which were used to govern the draught, being precisely the same. Coke effected a greater evaporation than coal at similarly rapid and slow rates of combustion; and in every case the temperature of an oil bath at the foot of the chimney was higher with coke than with coal. It must, however, be remarked, that no process had been used to ignite the gases which escaped from the furnace uninflamed. He had tried different kinds of coke, coal, and anthracite at this boiler, and the same fuel in every instance performed a greater evaporative effect at a slow than at a rapid rate of combustion. He thought that much of the air which entered the grate of a boiler passed through the fire unconsumed, for want of time to effect a sufficiently intimate combination with the fuel. In some experiments lately made at Swansea on the properties of anthracite, Dr. Schafœutl had found from analysis, that no less than 40 per cent. of the products of combustion taken from the chimney consisted of oxygen, yet he had effected the large evaporation of 11 lbs. of water with 1 lb. of that fuel.

Mr. Field stated, that Mr. Cooper had expressed an opinion that in the use of coke as a fuel, a less portion of heat reached the chimney than with coal, on account of the large quantity of unconsumed air that passed through the fire, owing to the open spaces necessarily existing between the pieces of such a dry fuel as coke; whereas in a fire made of binding coal, nearly the whole of the air combined with the fuel in its passage through the body of fire.

Mr. Pellatt observed, that although in practice coke appeared to require more air to support combustion than coal did, yet long experience had taught him to believe that when coal was exposed to a rapid combustion, it required more air than coke.

In answer to an observation that some experiments lately made on the measurement of the quantity of air which entered the blast furnaces of Sir John Guest at the Dowlais Iron Works might bear on this subject—Mr. Farey objected to the application of such results to determine the question, as the air is injected with considerable force into a furnace; there is frequently a great reflux of blast from the Tuyere when the furnace is working close; whereas when it is working open the flame at the top shows that the passage of the air through the mass of burning fuel is very free, and that consequently a portion of it passes off unconsumed. He had found in his experiments on blast furnaces, that unless there was a redundancy of carbon, and a deficiency of oxygen, there was no chance of making good iron.

May 26, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:—Thomas Illman, Joseph Chessborough Dyer, and G. S. Saunderson, as Associates.

"On a new Mode of Covering Roofs with Planking." By William Cubitt, Assoc. Inst. C. E.

A new mode of covering roofs with boards.

The roof itself is framed in the usual manner with principals and purlins, but without rafters. The boards intended for the covering are cut, by means of a circular saw, from planks 7 inches wide by 2½ inches thick, in such manner that each plank makes two boards, the one tapering from its centre towards the edges, the other from its edges towards the centre. The hollow boards are laid side by side, at intervals of 4½ inches, and nailed to the purlins by their centres only, so as to admit of shrinking; the intervening spaces are then covered by the other boards, overlapping 1¼ inch on each edge, and nailed in like manner. The covering thus formed presents a series of alternate elevations and depressions, longitudinally from the ridge to the gutter, and consequently the rain falls off very rapidly, and a roof so constructed is easily kept water-tight. The author conceives this to be the most economical mode of using timber for covering, and he has adopted it extensively. The communication was accompanied by a model of the roof and specimens of the boards as they are left by the saw.

Remarks on the engines of the steam tug 'Alice.'

A letter was read from Ardaseer Cursetjee, of Bombay, inviting a discussion on the relative advantages of long and short connecting rods for marine engines. He was induced to make inquiry on this subject from some observations in a communication to the Institution, relative to the engines of the steam tug the "Alice" (Minutes of Proceedings, page 54). In that paper their superiority is in part attributed to the increased length of the connecting rods. This is the point upon which he requests information, as he conceives that the power of the piston upon the crank is the same whatever may be the medium through which it is transmitted, and the effect to be the same throughout a complete revolution, whether the connecting rod be long or short, except that from the increased angle of a very short connecting rod some additional friction is thrown upon the joints.

On the general construction of the engine of the "Alice," he remarks, that engines of similar form are now used for pumping at the Thames Tunnel under Mr. Brunel's direction; and that a pair of engines of this kind were built by Messrs. Seaward, 13 years ago, for the "Staadt Francfort" steam boat, to ply between Francfort and Coblentz; in this instance, the cylinders were firmly fixed to the bed-plate and sleepers, with the cross bars above the cylinders, thus having one connecting rod only leading to the cranks, which he considers a superior arrangement to that of the engines of the "Alice."

A drawing of the engines of the "Staadt Francfort" accompanies the communication.

The action of the worm on Kyanized timber.

A letter was read from Mr. John Cooper, of Dover, describing the effect of the worm (*Teredo navalis*) on several kinds of timber which had been exposed to the action of sea water. The kinds of timber on which the experiments were made were fir, English oak, and African oak; specimens of each sort, some Kyanized and the others unprepared, having been tried under exactly similar circumstances on the piles of the south pier of Dover harbour. The results show that Kyanizing timber does not in any degree protect it; as, after exposure from December 1837 until May 1840, it was found that the worm made equal ravages among all the specimens. The author also tried the process of saturating timber with copperas water, but did not find any good result from it. In July 1835, he placed under water some 2-inch oak planks which had been prepared with copperas; and on examining them in May 1840, they were found to be as much attacked by the worm as the worst specimens of unprepared fir timber which had been exposed for a similar length of time. The African oak resisted the attack of the worm better than either fir or English oak.

It was stated that Teak timber resisted the attacks of the worm and of the white ant, which destroy all other kinds of timber. It is, however, liable to injury from the attacks of barnacles.

"On the Corrosion of Cast and Wrought Iron in Water." By Robert Mallet, Assoc. Inst. C. E., &c.

Corrosion of cast and wrought iron in water.

This communication is one of those forwarded to the Institution in consequence of the Council having considered this subject a suitable one to compete for the Telford Premiums; and the author having been long engaged in making experiments on this subject at the request of the British Association, refers in the introductory part of this paper to the contents of that report, which may be viewed as a "*précis*" of the state of our knowledge on the subject to the year 1839, together with original researches forming the basis of the present results. This communication is accompanied by a most elaborate set of tables of results; but these laborious investigations being yet in progress, the author directs his special attention to so much only of the subject as may be necessary for their elucidation, divesting his remarks as much as possible of a purely chemical character, and confining them to those practical conclusions which are of immediate use and importance to the engineer.

Tables.

The tables of results are altogether twelve in number. The first five contain the data and results of the chemical or corroding action of sea and fresh water on cast and wrought iron under five several conditions, during a period of a year and ten months; and these five series of experiments are so co-ordinate with each other as to form one connected and comparable whole, whence the relative rates and absolute amounts of corrosion of cast and wrought iron—by, 1. clear sea water, 2. foul sea water, 3. clear sea water at temperature 115° F., 4. foul river water, and 5. clear river water—may be ascertained. The corrosive action of water and air combined produces on the surface of cast or wrought iron a state of rust possessing one of the five following characteristics—1. Uniform, 2. uniform with plumbago, 3. local, 4. local pitted, 5. tubular—or of two or more of these characteristic conditions in combination; these facts for 82 different specimens of British and Irish cast iron—together with their original external characters, mode in which they were cast, specific gravity, dimension and weight before and after immersion, loss of weight per square inch of surface, this loss referred to a standard bar, and the weight of water absorbed for clear sea water—compose Table I. The four subsequent tables contain similar results for specimens of iron immersed under the other four conditions mentioned above. These five tables contain also the results of the corrosion of certain cast irons protected by either of ten several paints or varnishes, the results of which are comparable with those for the unprotected iron. Table VI. exhibits a general comparison of the results set forth in the preceding tables for specimens of iron

1 inch thick, and reduced to one common or equal period of immersion. Table VII. shows the *average loss* of all varieties of cast iron experimented on per square inch of surface. Table VIII. the average calculated amount of corrosion (assumed uniform) of various specimens of cast and wrought iron per superficial foot of surface at the end of one century. From these tables it appears, that the metallic destruction or corrosion of the iron is a maximum in clear sea water of the temperature of 115° F.—that it is nearly as great in foul sea water—and a minimum in clear fresh river water.

Iron piling in tidal rivers.

Iron under certain circumstances is subject to a peculiar increase of corrosive action—as, for instance, cast-iron piling at the mouth of tidal rivers—from the following cause. The salt water being of greater density than the fresh, forms at certain times of tide an under current, while the upper or surface water is fresh; these two strata of different constitution coming in contact with the metal, a voltaic pile of one solid and two fluid elements is formed; one portion of the metal will be in a positive state of electrical action with respect to the other, and the corrosive action on the former portion is augmented. The lower end of an iron pile, for instance, under the circumstances just mentioned, will be positive with respect to the other, and the corrosion of the lower part will be augmented by the negative state of the upper portion, while the upper will be *itself* preserved in the same proportion. From this theoretical view may be deduced the important practical conclusion, that the lower parts of all castings subject to this increased action should have increased scantling.

Action of foul sea water.

The increased corrosive action of *foul sea* water may be referred to the quantity of hydrosulphuric acid disengaged from putrifying animal matter in the mud, converting the hydrated oxides and carbonate of iron into various sulphurets, which again are rapidly oxidized further under certain conditions, and becoming *sulphates* are washed away. Hence the rapid decay of iron in the sewage of large cities, and of the bolts of marine engines exposed to the bilge water. The corrosive action being least in fresh water may be partly referred to this being a worse voltaic conducting fluid than salt water.

Action of hot sea water.

It appears also that wrought iron suffers the greatest loss by corrosion in hot sea water; which fact has led the author to inquiries, with reference to marine boilers, at what point of concentration of the salt water, whether when most dilute, after the common salt has begun to deposit, or at a farther stage of concentration, the corrosive action on wrought iron is the greatest, and he points out the important practical use which can be made of this information. It appears also, that the removal of the exterior *skin* of a casting greatly increases the corrosive action of salt water and its combined air, so that the index of corrosion under these circumstances is not much less than that of wrought iron, and in clear river water is greater.

Chilled cast iron.

It farther appears, that chilled cast iron corrodes faster than the same sort of cast iron cast in green sand, and that the size, scantling, and perhaps form of a casting, are elements in the rate of its corrosion in water. The explanation of these facts is to be found in the want of homogeneity of substance, and the consequent formation of numerous voltaic couples, by whose action the corrosion is promoted. It is also observable that the corroded surface of all these chilled specimens is tubular.

It appears also that, in castings of equal weight, those of massive scantling have proportionately greater durability than those of attenuated ribs and feathers. Hence appears also the great advantage of having all castings, particularly those intended to be submerged, *cooled in the sand*, so as to insure the greatest possible uniformity of texture. The principles now stated afford an explanation of the fact often observed, that the back ribs of cast-iron sheet piling decay much faster than the faces of the piles. It is also probable that castings in dry sand and loam will, for these reasons, be more durable than those cast in green sand. The general result of all these experiments gives a preference to the Welsh cast iron for aquatic purposes, and to those which possess closeness of grain. Generally, the more homogeneous, the denser and closer grained, and the less graphytic, the smaller is the index of corrosion for any given specimen or make of cast iron.

Welsh cast iron.

Protection by paint.

The author next proceeds to the important question of the protection afforded by paints and varnishes. White lead perishes at once in foul water, both fresh and salt; and caoutchouc dissolved in petroleum appears the most durable in hot water, and asphaltum varnish or boiled coal tar laid on while the iron is hot under all circumstances. The zinc paint, which is now so much noticed as an article of commerce, the author has analyzed, and states its composition as—

Sulphuret lead	9.05
Oxide zinc	4.15
Metallic zinc	81.71
Lesqui oxide iron	0.14
Silica	1.81
Carbon	1.20
Loss	1.94
	100.

It may, *a priori*, be considered likely to produce a most excellent body for a sound and durable paint under water. The black oxide of manganese has no advantages but that of being a powerful drier. The defects of all oil paints arise from the instability of their bases; the acids which enter into the constitution of all fixed oils readily quit their weakly positive organic bases to form salts with the oxides of the metal on which they may be laid. Hence we must look for improvements in our paints to those substances among the organic groups which have greater stability than the fat or fixed oils, and which, in the place of being acid or Haloid, are basic or neutral. The heavy oily matter obtained from the distillation of resin, called "resenien," and eupion, obtained from rapeseed oil, have valuable properties as the bases of paints.

Metallic protectors (brass).

Tables IX. and X. contain the results as to the corrosion of cast iron in sea water when exposed in Voltaic contact with various alloys of copper and zinc, copper and tin, or either of these metals separately, per square inch of surface. It appears that neither brass nor gun metal has any electro-chemical protective power over iron in water, but on the contrary promotes its corrosion. This question is only a particular case of the following general question: viz. if there be three metals, A. B. C., whereof A. is electro-positive, and C. electro-negative, with respect to B., and capable of forming various alloys, $2A + C \ldots A + C \ldots A + 2C$; then if B. be immersed in a solvent fluid in the presence of A., B. will be electro-chemically preserved, and A. corroded, and *vice versa*. If B. be so immersed in the presence of C., B. will be dissolved or corroded, and C. electro-chemically preserved; the amount of loss sustained in either case being determined according to Faraday's "general law of Volta-equivalents." The tables show that the loss sustained by cast iron in sea water, as compared to the loss sustained by an equal surface of the same cast iron in contact with copper, is 8·23 : 11·37; and when the cast iron was in contact with an alloy containing 7 atoms of copper and 1 of zinc, the ratio was 8·23 : 13·21; so that the addition in this proportion of an electro-*positive* metal to the copper produces an alloy (a new metal, in fact) with higher electro-negative powers, in respect to cast iron, than copper itself. The author discusses many results equally remarkable, and is therefore enabled to suggest by its chemical notation the alloy of "no action," or that which in the presence of iron and a solvent would neither accelerate nor retard its solution, one of the components of this alloy being slightly electro-negative, and the other slightly electro-positive, with respect to cast iron. These results will also enable some advances to be made towards the solution of the important problem proposed by the author in his former report, viz. "the obtaining a mode of electro-chemical protection, such that while the metal (iron) shall be preserved, the protector shall not be acted on, and the protection of which shall be invariable."

Metallic protectors (gun-metal).

Table X. exhibits especially the results of the action of sea water on cast iron in the presence of copper and tin or their alloys. It appears that copper and tin being *both* electro-negative with respect to cast iron, all their alloys increase or accelerate the rate of corrosion of cast iron in a solvent, though in very variable degrees; the maximum increase is produced by tin alone, thus indicating that this metal (contrary to what was previously believed) is more electro-negative to cast iron than copper. Hence the important practical deduction, that, where submerged, works in iron must be in contact with either alloy, viz. brass or gun metal; common brass, or copper and zinc, is much to be preferred. These experiments will also serve to demonstrate the fallacy of many of the patented so-called preservatives from oxidation, which are brought before the public with so much parade.

Specific gravity of cast iron.

The author lastly proceeds to the subject of the specific gravity of cast iron, tables of which are added to the preceding. The specific gravities here recorded were taken on equal sized cubes of the several cast irons cut by the planing machine, from bars of equal size, cast at the same temperature, in the same way, and cooled in equal times. Many of these results differ considerably from those given by Dr. Thompson and Mr. Fairbairn; which the author refers to the probability that those of Dr. Thompson were taken from pieces of the raw pig, and those of Mr. Fairbairn by weighing in air equal bulks cut from the mass by the chisel and file, by which latter process the volume is liable to condensation. The experiments of Mr. Fairbairn and Mr. Eaton Hodgkinson seem to show that the ultimate strength of cast iron is in the ratio of some function of the specific gravity dependant upon the following conditions: viz. 1. the bulk of the casting; 2. the depth or head of metal under which the casting was made; 3. the temperature at which the iron was poured into the mould; and 4. the rate at which the casting was cooled.

Nomenclature of fracture.

Table XI. All the irons experimented on are arranged in classes, according to the character of the fracture; for which purpose the terms —1. silvery, 2. micaceous, 3. mottled, 4. bright grey, 5. dull grey, and 6. dark grey, have been adopted by the author as a sufficient basis on which to rest a uniform system of nomenclature for the physical characters of all cast irons, as recognisable by their fracture; and it is to be wished that experimenters in future would

adopt this or some other uniform system of description, in place of the vague and often incorrect characteristics commonly attached to the appearance of the fracture of cast iron.

Increase of density in large castings.

The twelfth and last table contains the results of a set of experiments on the important subject of the increase of density conferred on cast iron, by being cast under a considerable head of metal, the amount of which condensation had not been previously reduced to numbers. It shows this increase of density in large castings, for every 2 feet in depth, from 2 to 14 feet deep of metal.

A very rapid increase of density takes place at first, and below 4 feet in depth a nearly uniform increment of condensation.

The importance of these results is obvious; for, if the ultimate cohesion of castings is as some function of their specific gravity, the results of experiments in relation to strength, *made on castings of different magnitudes, or cast under different heads*, can only be made comparable by involving their variable specific gravities in the calculation.

June 2, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected:— Lieutenant T. H. Sale, B.E., and George Larmer, as Associates.

June 16, 1840.

The PRESIDENT in the Chair.

The following were balloted for and elected: William Jory Henwood, as a Member; John Thomas Cooper and John Oliver York, as Associates.

"On the Action of Steam as a Moving Power in the Cornish Single Pumping Engine." By Josiah Parkes, M. Inst. C. E.

Action of steam in Cornish pumping engines.

In this communication, the author presents a detailed analysis of some of the facts collected and recorded by him in his former communications, with the special object of ascertaining from the known consumption of water as steam, the whole quantity of action developed—the quantity of action had it been used unexpansively—the value of expansion—the correspondence between the power, and the resistance overcome—and, finally, a theory of the steam's action, with a view of determining the real causes of the economy of the Cornish single pumping engine.

Data employed.

The data employed for the purposes of this investigation are those obtained from the Huel Towan engine by Mr. Henwood, from the Holmbush by Mr. Wicksteed, and from the Fowey Consols, and recorded in the author's communications in the Transactions of the Institution of Civil Engineers, Vols. 2 and 3.

Methods of applying steam.

Steam may be applied in one or other of the two following modes: expansively, that is, when admitted into the cylinder at a pressure greater than the resistance, and quitting it at a pressure less than the resistance; or unexpansively, that is, when its pressure on the piston is equal to the resistance throughout the stroke. By the term *economy* in the use of steam, is meant the increase in quantity of action obtained by the adoption of that mode which produces the greatest effect.

Absolute resistance to the steam.

The weight of pump-rods, &c., which effects the pumping or return stroke in a Cornish engine is greater than the weight of the column of water, by the amounts necessary to overcome the friction of the water in the pipes—to displace the water at the velocity of the stroke—to overcome the friction of the pitwork, and of the engine itself. The absolute resistance opposed to the steam, consists of the weight which performs the return stroke, plus the friction of the engine and pitwork, and the elasticity of the uncondensed steam.

Steam's force at the end of the working stroke.

The water-load in the Huel Towan engine was very accurately ascertained as 11 lbs. per square inch on the piston; and it is shown that the additional resistance amounted to 7 lbs. in the Huel Towan, and to 6 lbs. in the other engines, so that the whole resistance in the Huel Towan engine is 18 lbs. per square inch of the piston. Now, the elastic force of the steam at the termination of the stroke, and before the equilibrium valve is opened (ascertained from the ratio of the volumes of steam and water consumed), is only 7 lbs. per square inch, that is, 4 lbs. less than the water-load alone. The corresponding results for the other two engines are equally remarkable, and show most distinctly that, at the termination of the stroke, the pressure of the steam is far below the water-load, as had been previously observed by Mr. Henwood and others.

Steam's expansive and unexpansive action separated.

The next step in the analysis is to determine the portion of the stroke performed when the pressure of the steam in the cylinder is just below the resistance, and then to separate and estimate the spaces through which the piston is driven respectively by steam of a pressure not less than the resistance, and less than the resistance. These facts being ascertained, the virtual or useful expansion, and the dynamic efficiency of the steam, during the two portions of the stroke, are known; and it appears that there is a deficiency of power, as compared with the resistance overcome, of above 3 lbs. in the Huel Towan, and more than 4 lbs. in the other engines, per square inch on the piston.

Deficiency of power.

From these startling facts, and a careful examination of Mr. Henwood's indicator diagrams, the author was induced to inquire whether the piston had not been impelled by a force altogether distinct from the continuous action of the steam upon it, namely, by a force which is to be referred to the sudden impact on the piston when the admission valve is so fully and instantaneously opened, as it is in these engines, and a free communication established between the cylinder and the boiler. To this instantaneous action on the piston, the author, for the sake of distinction, assigns the term *percussion*: and, proceeding to analyse the authentic facts under this view, it appears that the space of the cylinder through which the piston was carried by virtue of this percussive action was about 21 inches in the Huel Towan, 27 inches in the Holmbush, and 33 inches in the Fowey Consols engines.

Percussive action of steam.

The results thus unfolded, which are facts independent of any hypothesis, appear less startling on a full consideration of the circumstances under which the steam is admitted into the cylinder. The engine has completed a stroke, and is brought to rest by the cushion of steam between the piston and the cylinder cover; a vacuum is formed on the other side of the piston; the elastic force of the steam in the cushion then nearly balances the resistance. A communication is now suddenly opened between the cylinder and the boiler containing steam of a high elasticity; and the piston, being ready to move with a slightly increased pressure, receives a violent impulse from the steam's instantaneous action. The piston having started, the influx of the steam is more or less retarded by the throttle valve, and its elastic force, though at first greater than the resistance, is soon reduced considerably below it, the mass of matter in motion acting the part of a fly wheel, absorbing the excess of the initial power over the resistance, and discharging it by degrees until the stroke is completed.

Conditions of a Cornish engine and theory of the steam's action.

The indicator diagrams, which are the transcripts of the piston's movements, show that such may be the nature of the action on the piston, and the discussion of numerous well-established facts and phenomena, for the Cornish engines, strongly confirms this view of the case. Whatever may be the theory of the steam's action, the fact that the sum of those actions has carried the piston through its course, is certain; and it seems equally certain that the quantity of water as steam which entered the cylinders was insufficient alone to overcome the resistance.

Action of the cushion of steam.

The author then investigates the amount of useful action due to the steam imprisoned between the piston and the cylinder cover, and recovered each stroke, which, for its use in bringing the engine to a state of rest at the end of the return stroke, he terms the *cushion*. This quantity, though small, is appreciable, and its value is assigned for each engine.

The author treats lastly of the evidence furnished by the diagrams of the indicator, and of its utility as a pressure gauge. The communication is accompanied by elaborate tables of the results of the analysis, and an appendix with the calculations worked out in detail.

Mr. Wicksteed being called upon by the President, declined at present giving an opinion upon the theory before the meeting. He stated, that he was still trying experiments upon the engine at Old Ford—that the results up to the present time were in accordance with his anticipations—that, with small screenings of Newcastle coals, the duty of the engine amounted generally to 75 millions, and sometimes to as much as 81 or 82 millions. He thought that 7 lbs. per square inch for friction and imperfect vacuum was too large an allowance for an engine of the size of that at Old Ford, as, when the speed was 10 to 11 strokes per minute, the power was equal to 200 horses, and, if an allowance of 6 or 7 lbs. was made, it would be equal to 100 horses' extra power, which he felt certain could not be correct. At the same time, he believed that in very small engines the amount of friction, &c., might be correctly estimated at 6 or 7 lbs. per square inch. He had also tried some experiments upon a Boulton and Watt low-pressure engine: by the introduction of Harvey and West's patent pump valves, the duty of the engine had been increased from about 28½ to 32½ millions. He was now trying experiments on clothing the cylinder, &c., and with steam in and out of the jacket: the result of all these experiments should be laid before the Institution as soon as they were completed.

Mr. Seaward considered the paper to be very valuable, as opening a new view of the action of steam, and inducing discussion and experiment; but he was not prepared to allow at once the percussive action, nor could he admit it to be the cause of the increased duty, as, if so, an augmentation of pressure in the boiler would give a corresponding increase of duty. Engines were worked at all pressures up to 60 lbs., and even higher; but it was not perceived that the highest pressure gave the best results. He attributed the increase of duty to an improvement in the manner of using coal under the boilers; to the use of good non-conducting substances for clothing the cylinders, steam-pipes, &c., to prevent the radiation of heat; and to the general improvement in the construction of the valves and other parts of the engines, the proper dimensions for which were at present better defined. The expansive principle did not seem to have operated so well in the rotary as in the pumping engines. He had not hitherto credited the statements of engines working with a consumption of coal of 5 lbs. per horse power per hour, nor of the great advantage of the use of steam at high pressures. Several Scotch boats had been worked with steam, at a pressure of 33 lbs. on the inch, without any corresponding advantage. The increase of duty, then, he attributed to other reasons than the effects of percussion, as, independent of other considerations, the steam must always have possessed the same percussive force, which it must have exercised without producing the effects now attributed to it.

Mr. Wicksteed observed, that there were many reasons why the duty of the double expansive engines in Cornwall was not in proportion to that of the single pumping engines. The introduction of the former only dated from about the year 1834; but few had been made; there had not been the same amount of experience to guide the engineer in their construction; they were of small size, and consequently the amount of the friction was greater in proportion than in the large single pumping engines. Notwithstanding all these disadvantages, the duty had increased from 15 or 20 millions to 57 millions. It had been stated that the double expansive engines constructed by Hall and by Penn did not consume more than 5 lbs. of coal per horse power per hour; while the ordinary low-pressure double engines required from 8 lbs. to 10 lbs. of coals. He would suggest to such members as possessed the power of verifying this fact to communicate their observations to the Institution.

Mr. Rendel would direct the attention of members to the main feature of Mr. Parkes's paper, which was the discovery of the action of a percussive force by the steam. The full investigation of this subject deeply interested the scientific world; and it was important that its merit should be clearly displayed. If any power could be gained from the percussive action, the more suddenly the steam could be admitted upon the piston, the more advantageous would be the result. It would be interesting to learn whether, in the changes in Cornish engines, from which such improved duty had resulted, any increased area had been given to the steam pipes and valves, and to what extent as compared with the old practice. If any change of this kind should be found to have taken place, it would be an argument in favour of the percussive principle.

Mr. Field expressed his sense of the obligations which the Institution owed to Mr. Parkes for having taken up this subject. It had been supposed by many persons that, independently of the economy arising from clothing the cylinder, jacket, and boilers, and the expansive action of the steam, some other cause might have assisted in producing the increase of effect in the Cornish engine. Doubtless, much had been done to economise heat and steam by the slow combustion of the fuel under the boilers, by diminishing radiation, and by expansive action. Nevertheless, the question to be solved was, Can these improvements account for the whole progressive advance in the duty from 40 or 50 to 90 millions? He trusted that Mr. Wicksteed would apply the indicator to his engine, and ascertain the pressure on the piston at every portion of the stroke.

Mr. Parkes remarked, that many observing men had conceived doubts of the sufficiency of the commonly-received theory of expansion to explain the excessive economy of the Cornish above the unexpansive engine. Some had recorded this opinion. Mr. Henwood found the steam's force in the Huel Towan engine unable to sustain the water-load alone. Messrs. Lean showed a similar deficiency of steam power in an engine at the United Mines; and Mr. G. H. Palmer was perfectly correct in his statement, that the absolute force of steam as commonly appreciated was inadequate to the performances assigned to it; but he was wrong in asserting that these effects had not been obtained, for they were indubitable.

As doubts had been expressed with regard to the accuracy and sufficient duration of the experiments selected as the basis of his analysis, he would state, that Mr. Henwood obtained the quantity of water consumed as steam, during a continuous observation of 24 hours, having previously measured the water discharged by a given number of strokes of the feed pump, and then counting the entire number of strokes made to supply the boilers during the experiment. The pump was used periodically, and its whole contents injected into the boilers at each stroke, so that no material error could arise as to the quantity of water consumed as steam. With respect to the resistance overcome, Mr. Henwood several times measured the whole height of the lifts in the most careful manner, not comprehending the fact of the steam's force being unequal to sustain the load of water alone. Not content with this, he measured the water discharged by the pumps, and found a near correspondence with the calculated quantity.

Mr. Parkes would prefer a short experiment on the consumption of water as steam to a long one, as more likely to be accurate. He had rejected the eight months' experiment on the United Mines engine, as being unsuitable for the purpose of his investigation; for, during so long a period, the boilers must have been several times emptied and cleaned, stoppages must have occurred, condensation, leakage, and other circumstances must also have taken place, which unfitted that experiment for analysis. Long experiments were the best for the practical determination of the duty done by coal; but the action of steam in performing that duty was altogether a separate consideration. The consumption of water as steam for a single stroke of the engine, if it could be obtained, would be all-sufficient for investigating its action in the cylinder, as the weight raised by a Cornish engine must be the same at every stroke. If any error existed in the statement of the water evaporated, it was more likely to be in excess than in deficiency; for it would be admitted that the conversion of 10½ lbs. of water into steam, by 1 lb. of coal, was not a common occurrence. Yet, granting this result to have been obtained, it appeared that there was not steam enough to overcome the resistance. Such was the result of the analysis of the Huel Towan and Fowey Consols engines, for which the evaporation was ascertained; and if less water had been converted into steam, the deficiency of power, compared with the effect, would necessarily have been still greater. Mr. Henwood's statement of the performance of the Huel Towan engine was confirmed by a previous trial of the same engine in 1828, conducted by a committee of twenty-one competent persons, when it appeared, after twenty-six hours' experiments, that 87,209,662 lbs. had been raised one foot by a bushel of coals. Mr. Henwood's experiment gave 81,389,900 lbs., so that in the analysis the lowest result was used.

It had been urged, that if any such force as percussion belonged to steam now, it always formed one of its properties. This was true; but it either may not have been well applied, or its effect not detected. The expenditure of power as derived from the quantity of water consumed as steam could not be determined so long as any condensation of steam took place in the cylinder; for whatever steam was there condensed had lost its power. The perfect clothing of the Cornish cylinders rendered the analysis of the action derived from a given quantity of water as steam nearly free from error.

Mr. Wicksteed had stated, that when he kept the steam out of the jacket of one of Boulton and Watt's engines, it required full steam throughout the stroke to overcome the load; whereas, with steam in the jacket, some expansion could be used. This would show a greater expenditure of power in one case to produce an equal effect. Such, however, could not be: an equal power operated in both cases; but in the one, a portion of it was annihilated, or had produced no useful effect.

Mr. Parkes considered it as demonstrated, that a force, independent of the steam's simple elastic force within the cylinder, did operate in the Cornish engines. The term *percussion* might be objected to when applied to an elastic fluid. Nevertheless, he conceived that the instantaneous action transmitted to the piston, on the sudden and free communication effected between the cylinder and boiler, must produce an effect analogous to the percussion of solids. He considered the proofs of such action adduced in his paper as irresistible.

He would ask how it could be accounted for that the steam was in a state of expansion during 19 out of 20 parts of the stroke in the Huel Towan engine, as shown by the indicator diagram, though it was freely admitted during one-fifth of the stroke, unless a velocity had been given to the piston by an initial force exceeding that of the steam's simple elastic force? How was it that, at the end of the stroke, the steam's elasticity was able to sustain so small a portion of the load in equilibrio, unless a momentum had been transferred to the mass by the impact on the piston, and aided the expanding steam to complete the stroke, which alone it was incompetent to perform? The greater degree of attenuation in which the steam was found on the completion of the stroke in one engine than in another, compared with the pressure of the resistance, and with the amount of expansion determined by the period of closing the valve, alone proved that the ordinary theory was inadequate to explain the action of steam in these engines.

He had for some time conjectured that a hidden and unsuspected cause influenced the performance of the Cornish engine; and if he had not been successful in discovering its nature, he considered the analysis as placing the fact beyond question, that the quantity of action resulting from the steam admitted into the cylinder was much below the force of the resistance opposed to it, and overcome.

June 23, 1840.

The **PRESIDENT** in the Chair.

John Frederick Bateman was balloted for and elected a Member.

"On the Stamping Engines in Cornwall." By John Samuel Enys, A. Inst. C. E.

Stamping engines in Cornwall.

The process of stamping or reducing the ores of tin, in Cornwall, by means of iron stamp-heads, which crush the ore in falling upon it, was formerly effected in mills worked by water power. These have been, from economical and other reasons, for the most part superseded by the use of steam; and even with inferior engines, the result has been such as to enable the poorer portions of the lode (which were frequently left in the mine) to be now advantageously worked.

Reported duty.

The work performed by the stamping engines was reported with that of the pumping engines, and showed the duty to be from 16 to 25 million lbs. raised one foot high by one bushel of coal, as estimated from the actual weight of the stamp-heads. The engines appropriated for this purpose were generally old double-acting engines of inferior character, and not unfrequently in a bad state of repair. The use of expansive steam was tried with good effect upon them, and induced Mr. James Sims to build an engine calculated more fully to develop the advantages of this principle. He accordingly, in the year 1835, erected one at the Charlestown mines. It was a single-acting engine, communicating the movement direct to the cam shaft for lifting the stampers without the intervention of wheel-work. The first reported duty, in December, 1835, was 43 millions, which was two-fifths more than had previously been performed by stamping engines. Subsequently, Mr. Sims erected other engines of similar construction, and from them may be taken the reported duty in April, 1840:—

Charlestown Mines	59,589,884 lbs.
Carn Brae	57,611,073 ,,
Wheal Ketley	58,748,452 ,,

This increased duty induced other engineers to turn their attention to the subject; and they have constructed engines which equal these duties; the chief variation being the adoption of double action, which seems generally to be preferred.

This paper is accompanied by four drawings of the Carn Brae stamping engine, by Mr. Sims, junior, showing in great detail the construction of the engine and the stamping machinery.

"On the Effects of the Worm on Kyanized Timber exposed to the Action of Sea Water, and on the use of Greenheart Timber from Demerara, in the same situations." By J. B. Hartley, M. Inst. C. E.

Effects of the worm on Kyanized timber.

There are probably few ports in England where the inconvenience resulting from the attacks of marine worms (*Teredo navalis*) on the timber of the dock gates and other works exposed to their action, is more severely felt than at Liverpool. The river Mersey has a vertical rise of tide of 27 feet at spring, and 13 feet at neap tides, and the stream being densely charged with silt, a considerable deposit takes place in the open basins, and to some extent in the docks. The latter are cleansed by means of a dredging machine; but the former are usually "scuttled," for which purpose sewers connected with the docks surround the basins, having several openings furnished with "clows," or paddles, so that the rush of water from the docks may be applied for clearing away the mud from any particular part of the basin. The security of these paddles is, therefore, of the greatest importance, as the failure of one of them might, by allowing a dock to be suddenly emptied, cause great damage to the shipping. These paddles have been usually constructed of English oak or elm, and being much exposed, they suffer from the attacks of the worms. Cast-iron paddles have been tried; but in consequence of the rapidity of the corrosive action, they soon became leaky, and were abandoned. Kyanized oak timber has been tried on the back of these paddles, and found to be perforated by the worm in the same time as unprepared wood. Some oak planks, two inches and a half thick, Kyanized at the Company's yard, were used on the west entrance gates of the Clarence Half-tide Basin, and in 14 months were completely destroyed. Several similar instances of the non-efficiency of the Kyanized timber are given; and the author proceeds to designate the timber which resists best in such situations. He considers that Teak is less liable to injury than English woods, and instances the inner gates of the Clarence dock, which have been built for 10 years, and at present are but slightly attacked.

Greenheart timber.

The timber which he prefers for dock works is the *Greenheart*. It is imported from Demerara, in logs of 12 to 16 inches square by 25 to 40 feet long, and costs about seven shillings per cubic foot. Of its power to resist the attacks of worms, he gives many proofs: one of them may be cited. At the first construction of the Brunswick Half-tide basin, several elm clows were placed at the west entrance; these were destroyed by the worms in two years, and were replaced by others made of greenheart; the joints of the plank being tongued with deal, to render them completely water-tight. These clows have now been down about seven years, and, although the deal tongueing has been destroyed by the worms, the greenheart planking remains untouched and perfectly sound.

Metallic protectors.

Many methods of protecting common timber have been tried; but the only successful ones adduced are—1st, the use of broad-headed metallic nails driven nearly close to each other into the heads and heels of the gates, but if driven an inch apart, the worm penetrates between them; and, 2dly, steeping the timber in a strong solution of sulphate of copper from the Parys copper mines in Anglesea. Some paddles made of English elm thus prepared had been in use upwards of three years, and, on an examination, were found to be very slightly injured; while the unprepared timber about them was quite destroyed.

The author observes, that the outer gates of the wet basins are most injured by the worm, from the sills being low down, and the change of water every tide assisting the growth of the worm. Those parts of the gates which are alternately wet and dry are more injured by the worm than the parts immersed always in the same depth of water. At the spot where a leak occurs from a bad joint, a defect in the caulking, or other cause, the worm commences its attack; so that the most incessant attention is required. Those basins into which the sewers of the town discharge themselves are comparatively free from the worm, from which it would appear that sulphuretted hydrogen gas acts in some measure as a protection against the attacks of the worm.

"An Account of the actual State of the Works at the Thames Tunnel (June 23, 1840)." By M. I. Brunel, M. Inst. C. E.

Thames Tunnel.

In consequence of local opposition, the works have not advanced much since the month of March, 1840; but, as that has been overcome, and facilities granted by the City, the works will be speedily resumed, and the shaft on the north bank commenced.

The progress of the Tunnel in the last year has been, within one foot, equal to that made in the three preceding years. During those periods collectively, the extent of the Tunnel excavated was 250 ft. 6 in., and during the last year the excavation has been

249 ft. 6 in. This progress has been made in spite of the difficulties caused by the frequent depressions of the bed of the river. These have been so extensive, that in the course of 28 lineal feet of Tunnel, the quantity of ground thrown upon the bed of the river, to make up for the displacement, in the deepest part of the stream, has been *ten times* that of the excavation, although the space of the excavation itself is completely replaced by the brick structure. On one occasion the ground subsided, in the course of a few minutes, to the extent of 13 feet in depth over an area of 30 feet in diameter, without causing any increased influx of water to the works of the Tunnel. The results now recorded confirm Mr. Brunel in his opinion of the efficiency of his original plan, which is "to press equally against the ground all over the area of the face, whatever may be the nature of the ground through which the excavation is being carried." The sides and top are naturally protected; but the face depends wholly for support upon the poling boards and screws. The displacement of one board by the pressure of the ground might be attended with disastrous consequences; no deviation therefore from the safe plan should be permitted.

The paper is accompanied by a plan, showing the progress made at different periods. It is stated that a full and complete record of all the occurrences which have taken place during the progress has been kept, so as to supply information to enable others to avert many of the difficulties encountered by Mr. Brunel in this bold yet successful undertaking.

June 30, 1840.

HENRY ROBINSON PALMER, V.P., in the Chair.

"Description of an Instrument for describing the Profile of Roads." By Henry Chapman, G. Inst. C. E.

Instrument for describing the profile of roads.

The object of the author in the invention of this instrument was to facilitate the mode of making a preliminary survey for railways by a machine of a simple construction, and composed of very few moving parts. It may be thus briefly described.

A light frame with springs and upon four wheels carries the machinery, to which a rotary movement is communicated from one of the wheels, which is keyed fast upon its axle. A double-threaded screw and a series of wheel-work give motion to a cylinder, upon which a length of paper is coiled; this cylinder revolves, and moves simultaneously in the direction of its axis. A pencil, which moves parallel to the axis of the cylinder, marks a line upon it, with a velocity varying according to the inclination of the road, and is so arranged, that when the machine is passing along a level, the motion of the pencil will equal that of the cylinder. In ascending inclined planes, it will be retarded, and in descending, it will be accelerated. By these means a rising or falling line will be accurately drawn. This variation in the action of the pencil is accomplished by means of a friction-wheel working against a cone, the different diameters of which regulate and determine the speed. The position of the friction-wheel upon the cone is determined by the change of position of a pendulum vibrating within a case which is filled with a dense fluid, for the purpose of rendering its action more uniform.

The machine will trace a section of a road in lengths of five miles upon each sheet of paper, to a horizontal scale of 20 chains per mile, and to a vertical scale of 200 feet to an inch. That no inconvenience may be felt from the smallness of the scale, the instrument is furnished with scales with sliding verniers, from which memoranda can be made of the distance run, and of the variations above or below the datum line. These memoranda are made upon a strip of paper, which is fastened on a table, along which an index travels at a velocity corresponding with that of the paper on the cylinder; so that the strip of paper being afterwards laid upon the section, the points marked may be squared down without using the scales.

When the distance of five miles is passed over, a bell gives notice of the working machinery being disengaged; the section is removed; a fresh sheet of paper is introduced, and, as the pencil maintains its position, the section will be carried on continuously.

This communication is accompanied by three working drawings, showing, on a large scale, the machine in action, and all the component parts in great detail.

"On the Efflux of Gaseous Fluids under pressure." By Charles Hood, F.R.A.S., &c.

Efflux of gaseous fluids.

The theoretical determination of the velocity with which gaseous fluids are discharged through tubes and apertures, has frequently been investigated by mathematicians; and as the question is one of importance in various branches of practical science, the author examines the several theorems which have been proposed for its elucidation, and compares them with the results obtained by experimental researches.

Dr. Papin, in 1686, appears to have first ascertained the law of efflux to be the same for both elastic and inelastic fluids, and the majority of the writers on the subject since his time have adopted as the fundamental *data* of their calculations, the hydrodynamic law of spouting fluids, by which the velocity of discharge is found to be proportional to the square root of the height of the superincumbent column of homogeneous fluid.

The author investigates particularly the methods of calculation proposed by Dr. Gregory, Mr. Davies Gilbert, Mr. Sylvester, Mr. Tredgold, and M. Montgolfier, and points out the differences which exist in their several methods. That of Mr. Sylvester is the only one which differs in any considerable degree from the simple law above stated; and his calculation is based upon the supposition that the respective columns of light and heavy air represent two unequal weights suspended by a cord, hanging over a pulley—by which mode of calculation, in the cases selected by the author for comparison, a result is obtained of only about one-third the amount given by the other methods. These calculations are compared with some experiments made by Sir John Guest at the Dowlais Iron Works, and also of Mr. Dufrenoy at the Clyde and at the Butterly Iron Works, recorded by him in his report to the Director-General of Mines in France. The results are tabulated; giving the pressure of the blast, the area of discharge, the velocity of the blast, the quantity of air ascertained by experiment, and the quantity shown by the several methods of calculation. From all these comparisons the author draws the conclusion that the method of calculation proposed by Montgolfier is the most accurate, as it is also the most simple. If the pressure be ascertained in inches of mercury, it is only necessary to find the column of air in feet equivalent to the pressure, and to multiply this number (as in the common case of gravitating bodies) by sixty-four feet, and then the square root of this product will give the velocity of discharge in feet per second. The equivalent height of the column of air in feet is found by multiplying the number of inches of mercury by 11,230 and dividing the product by 12, mercury being 11,230 times the weight of air. Allowing for a small loss by friction in the quantity found by experiment, the agreement between the theoretical and experimental quantities is extremely near. Rules are likewise given for applying these calculations to other gases of different specific gravities, which are also applicable to chimney draughts and to the expansion of air by heat.

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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1841.

ANNUAL REPORT.

Annual Report.

The Council of the Institution of Civil Engineers, on resigning the trust which has been confided to them during the past year, invite the attention of the Annual General Meeting and of all who are interested in the progress of practical science, to the following report on the discharge of their various duties, and on the general nature of the proceedings of the past year.

The Annual Report of the Council of several preceding years has dwelt in considerable detail not only on alterations in the ordinary business of the Institution, and on the introduction of measures which might tend to the convenience of the general body, but also on changes of a more important character, affecting the constitution and permanent stability of the Institution itself. The year which has now past has not been marked by any features of this nature. The principal duty of the Council has been to carry out and persevere in the practice and regulations established during previous years, which have been found to contribute so much to the rapid growth and increasing value of the Institution.

But, though the past year may not have been marked by extensive changes or by the introduction of new regulations, it has been characterized by events of great interest, and the proceedings of the last session surpass in extent those of any previous year. The extended importance of the Institution has imposed an augmentation of duty and responsibility on your Council, and they have laboured so to direct the affairs intrusted to them, that the discharge of those increased duties might be attended with a corresponding elevation in the character of the Institution, and that their successors in office may realize a still further progress towards that eminence which is already in some measure attained.

Telford Premiums. Among the various duties which devolve on your Council, that of disposing and awarding the Telford Premiums is of the highest consequence, and on the proper discharge of which much of the permanent success of the Institution will depend. The Council, deeply impressed with this, have given their most careful consideration to the subject; they would direct your attention to the following notice of the premiums, and of the respective communications for which they have been awarded.

Mr. Parkes In the Annual Report of the last Session, the Council stated that it would be one of the earliest duties of their successors to consider in what manner the benefits conferred by your member Mr. Parkes on practical science, by the communications then alluded to, could be most appropriately acknowledged; and the present Council, concurring most fully in these sentiments, are of opinion, that as no papers have hitherto been received by the Institution, exhibiting so much originality, labour, and ingenuity, in dealing with the facts presented to his notice, combined so essentially with practical utility, they are warranted in conferring on Mr. Parkes the highest honour which the Institution has in its power to bestow. They have awarded, therefore, the Telford Gold Medal to Mr. Parkes, for his communications on "Steam Boilers and Steam Engines," which are now published in the first and second parts of the third volume of the Transactions. These papers and the discussions to which they gave rise, occupying as they did the attention of several of your meetings, together with the interest which they excited, must be fresh in the recollection of all who were present. It will therefore be unnecessary to dwell particularly on their contents; but, inasmuch as the highest honour of the Institution has been awarded to them, an honour which (it must be remembered) has been but once previously conferred, the Council feel it to be a duty which they owe to the Institution, to themselves, and to the Public, no less than to the Author, to point out (as has been partially done in the Report of the last year) some of the principal features in these communications, and the peculiar benefits which are thereby conferred on practical science.

These communications are the continuation of the labours of the author, which commenced with the paper on the "Evaporation of water from Steam Boilers," published in the second volume of the Transactions, and for which a Silver Medal was awarded on a previous occasion. The first communication, forming the subject of the present notice, relates especially to Steam Boilers, respecting which many well-ascertained facts had been collected; but previously to Mr. Parkes devoting his attention to this subject, no clear and connected view had been given of the various facts, or of their relation to each other, and to the circumstances under which they are exhibited. When so represented, it appears that the peculiar circumstances under which Steam Boilers are employed and their corresponding qualities and characteristics in respect of construction, proportion of parts, and practical management, present certain quantities and relations, which exert a peculiar influence over the results connected with evaporation; and these being clearly developed and understood, indicate correctly the character of the boiler. Certain definite quantities, relations, or exponents, with other facts of paramount importance, such as the effect of the element time, or the period of the detention of the heat about the boiler, and various actions independent of the temperature of the fire, and tending to the destruction of the boiler, are here for the first time pressed on the attention of the practical Engineer. In the second communication, the author traces the distribution and application of Steam in several classes of Steam Engines. In the execution of this task, he is led into a detailed examination of various important questions: the best practical measure of the dynamic efficiency of steam,—the methods employed to determine the power of engines,—the measures of effect,—the expenditure of power,—the proportions of boilers to engines,—the standard measure of duty,—the constituent heat of steam,—the locomotive engine,—the blast and the resistance occasioned by it,—the momentum of the engine and train, as exhibiting the whole useful effort exerted by the steam,—and the relative expenditure of power for a given effect, by fixed and locomotive non-condensing engines. The bare enumeration of the principal subjects which have been carefully analysed and illustrated by the facts applicable to each respective case, will give some idea of the magnitude of the task here undertaken; and when in addition is considered the elaborate and extensive series of tables exhibiting the results and analysis of the facts collected and used in the course of the inquiry, the Council cannot but feel that a more laborious task has rarely been accomplished. A peculiar feature of these communications, and one to which the Council would particularly advert, is, that they are not of a speculative character, but present a detailed analysis of authenticated facts.

This analysis consists in separating and ascertaining the various results, and in referring them to particular classes, so that they may be readily applicable in practice. The merit of instituting and recording a series of observations upon a scientific subject is universally acknowledged, but the reduction of such observations so as to form a standard of reference to which the practical

Engineer may appeal, is a task of far greater difficulty, and its execution of far higher merit. It is in this eminent rank that the Council would place these communications of Mr. Parkes.

Mr. Leslie. The description by Mr. Leslie of the Harbour and Docks of Dundee, was also briefly adverted to in the last Annual Report, as one of those communications on which the Institution sets great value. It consists of a detailed account of the progress of the improvements projected by Smeaton, Telford, and others, in part carried into execution by the projectors, and completed under the author's own superintendence since 1832. The illustrations of the projected and executed improvements with the plans, elevations, sections, and details of the works of the Docks, Gates, Quays, Cranes, and Machinery employed, occupy 36 sheets of drawings. To the copious history and description of these works is added an extensive series of observations on the Tides. The determination of these facts for different parts of the globe, is a question of the greatest importance in physical astronomy, and the Council would take this opportunity of pointing out the essential service which may thus be rendered by the Engineer to the cause of science by his recording the observations which *he* has pre-eminently the opportunity of making. For this valuable record of an executed work, the Council have awarded a Silver Medal and a copy of the Life and Works of Telford.

Mr. Mallet. A Silver Medal and the Life and Works of Telford have been awarded to your Associate, Robert Mallet, for his communication on the "Corrosion of Cast and Wrought Iron in Water." This communication presents features of no ordinary interest to the Engineer. The comparatively recent introduction of Cast iron for the purposes of piling, for wharfs, &c. and of Wrought iron in the construction of vessels, has rendered the subject of the action of water upon iron of peculiar importance; the British Association have from time to time granted sums of money, for making experiments on this subject, and Mr. Mallet having been engaged in conducting these experiments, has selected from the very extensive series of results obtained by him, those conclusions which may be of service to the practical Engineer. The most valuable portion of this communication consists of elaborate tables; which exhibit the results of the action of clear and foul sea and fresh water at different temperatures upon cast and wrought iron. Such being the general nature of the experiments, the results to which they lead, or the effects produced, present several remarkable characteristics, and it is found that the corrosive action of water and air combined, produces on the surface of cast or wrought iron, a state of rust possessing one of five distinctive features, viz., uniform,—uniform with plumbago,—

local,—local-pitted,—tubercular, or some two or more of these in partial combination. The practical results which may be deduced from these tables are of the highest value to the Engineer, and point to considerations of the greatest importance; thus the upper and lower strata of water, of different degrees of saltness and density, coming in contact with the same mass of iron, a voltaic pile of one solid and two fluid elements is formed, and under such circumstances the corrosive action is materially augmented; hence it follows as a practical conclusion, that the lower part of all castings used in such situations, should be of increased dimensions. Similar results, the knowledge of which is of great importance to the practical Engineer, such as the rapid decay of iron in the sewage of large cities, of the bolts of marine engines exposed to the bilge water, and of boilers containing hot Sea water, are referred to actions due to similar physical principles. The protection which metals receive from paint, or from the presence of various alloys, so as to obtain a mode of electro-chemical protection, such that, while the metal iron shall be preserved, the protector shall not be acted upon, is also referred to similar principles.

The Council have also awarded a Bronze Medal and Books to Mr. Charles Bourns, for his Communication on "setting out Railway Curves;" to Mr. Chapman, for his description and drawings of "a machine for describing the profile of a Road," and to Mr. Henry Renton, for his description and drawing of "a self-acting Waste-board on the River Ouse."

Mr. Bourns

The communication by Mr. Bourns is an application of simple geometry, leading to practical results. In setting out curves recourse has been had to various expedients, but Mr. Bourns, in the propositions contained in this paper, has shewn that, by the use of the common chain, an offset staff, and table of offsets, he is enabled to set out curves of any radius and flexure, with a facility and precision not generally attained.

Mr. Chapman.

The description and drawings of a machine for describing the profile of a road, is one of several communications on this subject, sent in accordance with the notice of subjects for competition issued by the Council. Many of the arrangements proposed by the author exhibit considerable ingenuity, and though difficulties may exist in their practical application, the Council think this attempt may be of assistance to others, who may have their attention directed to the construction of an instrument for similar purposes.

Mr. Renton.

The description and drawing of the self-acting Waste-board on the River Ouse, being an account of an executed work, is one of those communications which the Council are most anxious to encourage by every means in their power. The drawing and description furnished by Mr Renton are highly creditable to the talents of the author, and deserving of some special mark of approbation.

Mr. Birch. The Council have also awarded Books to the value of Five Guineas to Eugenius Birch, for his drawing and description of the machine for Sewing Flat Ropes, in use at Huddart's Rope Manufactory. The rope machinery of Captain Huddart was, some time since, one of the subjects on which the Council solicited communications; on that occasion two valuable sets of drawings were communicated, the one by Mr. Dempsey, the other by Mr. Birch. The subject of the present communication was not included in either of the preceding, but Mr. Birch, desirous of availing himself to the fullest extent of the liberality of Mr. Cotton, the then proprietor of the machinery, and of carrying out the views of the Council, has devoted much time and labour to placing in the Institution, an exact record of every thing connected with this interesting machinery.

Mr. Maude Premiums of Books have also been awarded to Mr. Maude, for his "Account of the Repairs and Alterations made in the construction of the Menai Bridge, rendered necessary by the gale of January 7, 1839," and to Mr. Andrew Burn, for his drawings of a "Proposed Suspension Bridge over the Haslar Lake." The Council would point out these instances of the fulfilment of the engagements entered into on election, to the attention of the other Graduates of the Institution, who have similar opportunities, but who have not hitherto kept their promises. It is the desire of the Council, to obtain an exact record of works that are projected or in progress, and such records are peculiarly adapted to compete for the Telford Premiums: Mr. Maude and Mr. Burn, with proper permission, have availed themselves of the facilities afforded them, and the Council trust that the premiums now awarded, and the marks of approbation here expressed, will stimulate others to avail themselves of like opportunities. The authors of such communications will thus most materially contribute towards promoting the interests of the Institution, and to their own qualification for future employment and advancement in the profession. Mr. Burn.

Original communications. The Institution has received during the past year, many other communications of acknowledged merit, of which no mention has yet been made. To a few of them the Council would now briefly advert, and especially to the last paper by Mr. Parkes, "On the action of Steam in the Cornish Single Pumping Engine," a communication of no ordinary importance and interest, either on account of its own intrinsic merits, as viewed in connexion with the past proceedings of this Institution, or the future prospects of this department of practical science. This communication, though intimately connected with those of the same author previously Mr. Parkes alluded to, growing immediately out of them, and depending upon the facts contained in them, is of a totally distinct character; being an attempt to explain, on theoretical principles, the action of the steam on the piston, and to unfold the real causes of the economy of the Cornish engines. This subject has occupied the attention of the Institution during the last four years, and the discussion first assumed a settled form during the Session of 1837, on the receipt of the communication of Mr. George Holworthy Palmer, "On the application of Steam as a moving power, especially with reference to the reported duties of the Cornish and other Engines." In that paper the author, reasoning on certain data as to evaporation, and on the physical facts which involved the constancy of the sum of the latent and sensible heat in steam of all elasticities, and of the absorption of heat by matter on dilatation, came to the conclusion that no power could be gained by expansive working, and that, consequently, this could not be the *cause* of the economy in Cornish engines. This discussion was revived in the ensuing Session by the communications of Mr. Wicksteed and Mr. Henwood, the former furnishing the first recorded experiment in which the water raised was actually weighed, the latter giving an extended series of most careful and detailed observations on the quantity of steam employed, the mode of its distribution, the duty performed by a given quantity of fuel, and the measurement of the water raised.

Taking for data the facts furnished by Mr. Henwood for the Wheal Towan, and by Mr. West for the Fowey Consols Engines, Mr. Parkes has analyzed the quantity of action obtainable from the quantity of water as steam consumed, and expanded to the extent used in those engines, and has found the steam's force unequal to the resistance overcome. After satisfying himself from various phenomena attendant on the working of these engines, that the amount of resistance opposed to the steam was not overrated, he was led to conclude that from the instantaneous and free communication effected between the cylinder and boiler of these engines, by the sudden opening of the large steam valves, a force must be transmitted to the piston, of a kind distinct from that of the steam's simple elasticity. This force he denominates the steam's *percussive action;* he adduces various proofs that this description of force has operated on the piston, and that it alone was equivalent, in the instance of the Fowey Consols Engine, to drive the piston through $\frac{27}{100}$ths of its stroke.

The author considers the effect produced on the piston of a Cornish Engine, by the sudden impact of highly elastic steam, to be similar to that obtained from water in the hydraulic ram. He has not in his paper entered on the consideration of the absolute amount of percussive force, which can be afforded by an aeriform fluid in motion—but has confined himself to the determination of the quantity of action, which he conceives to have been derived from that source in the particular engines examined. He invites the cooperation of others in instituting experiments on this subject, and the Council hope that the ensuing Session will augment the number of facts requisite for the complete demonstration and development of this view of the steam's action.

It is gratifying to reflect how much the present state of our knowledge is due to the discussions which have taken place at the meetings of the Institution. The Council look forward with great interest to the revival of these discussions, and for some valuable communications on this subject which are promised by Members who have daily opportunities of making observations and experiments on an extensive scale.

Captain Basil Hall.

Among the other communications, the Council would briefly advert to that by Captain Basil Hall, on obtaining for Lighthouses all the advantages of a fixed light, by means of refracting lenses in revolution. It occurred to that distinguished officer that by placing a Fresnel lamp in the centre of an octagonal frame, having a lens inserted in every side, and causing the frame to revolve at a considerable velocity, a fixed or continuous light would be produced almost equal in brilliancy to the intermittent light from the same lamp when the frame revolved slowly.

Many curious effects are observed; thus, when the lenses are first set in motion the effect is a series of brilliant flashes; as the velocity increases, the light becomes more continuous—at about 44 revolutions per minute, absolute continuity is produced—and at 60 revolutions nearly the steadiness of a fixed light is attained. It would appear that the sensibility of the retina is affected by the succession of bright flashes, so that, judging by its intensity when seen through coloured glasses, the light would appear to suffer but little apparent diminution.

Mr. Gordon.

Another subject rather novel in its nature, but of considerable interest to the profession, on the "Application of Photography to the purposes of Engineering," was brought before the Institution, by your Member, Mr. Alexander Gordon. The facility with which this discovery may be applied to taking accurate views of buildings, works, or machinery at rest, renders it an object of great interest to Engineers; since by these means may be obtained the general dimensions of works, with perfect accuracy in a very small space of time, and by affixing a graduated scale to the objects to be copied, the photographic delineation would present the means of determining the dimensions of every part.

Mr. Cooper

The Council cannot omit this opportunity of acknowledging the obligations which the Institution is under to Mr. Cooper and Mr. Cooper, Jun., who illustrated the preceding communication, by exhibiting and explaining the apparatus requisite for the production of the delineations of photography.

Presents.

The Council have to acknowledge the receipt of many valuable presents during the past year; and to record the liberality and zeal thus exhibited in the promotion of the interests of the Institution.

By the liberality of your President and of Mr. Burges, you are in possession of two portraits upon which every British Engineer must look with feelings of great pride and satisfaction. To the President you owe the beautiful portrait of Huddart, now suspended in your Meeting Room, and to Mr. Burges that of Smeaton, which adorns the walls of the Library.

The Institution has to acknowledge the continuation of the liberality of the Master-General of the Ordnance, of the Lord Lieutenant of Ireland, and of Colonel Colby, in transmitting the sets of Ordnance Maps as they are published.

The Council has also to acknowledge the receipt of some additional works from the library of the late Dr. Young, presented by his brother, Mr. Robert Young, whose liberality in making the Institution the depository of a large number of the works of that distinguished philosopher and benefactor to practical science, the Council of the preceding year had also to record in a similar manner. The Institution has also received a valuable set of Charts of the Coast of France, published under the direction of the French Government, from your President; a number of books from the Minister of Public Works at Brussels, collected by your Secretary during a recent visit to Holland and Belgium, when a communication was established between the Institution and the Ministry of Public Works of those countries; the Transactions of the Royal Institute of Naples from Colonel Cuciniello, through Mr. Albano; a valuable set of Crane Drawings from Mr. Leslie, and Drawings of the Carn Brae Stamping Engines from Mr. Sims, through Mr. Enys; some interesting models from Mr. Hick, a Pneumatic Mirror of his invention from Mr. Nasmyth, and a Radiating Stove Grate for the Library, from Mr. Sylvester; to these must be added the very numerous List contained in the Appendix to this Report.

Obituary.

The Institution has to regret the loss by death, of Mr. Francis Bramah, Mr. Oldham, Mr. Rowles, and Mr. Rickman; individuals distinguished for their attainments in professional and general knowledge, and endeared to the Institution by long association and deep attachment to its interests.

Mr. Bramah.

Francis Bramah was the second son of the late Mr. Joseph Bramah, whose numerous inventions, perfection of workmanship, and genius in the mechanical arts, have rendered his name so widely and justly celebrated. The opportunities afforded to the son were ardently embraced by a mind of no ordinary powers, deeply imbued with the love of knowledge. Although his attention was in early youth more particularly directed to branches of minute mechanical construction, his acquaintance with the principal departments of professional knowledge and general science was very extensive. His attachment to the arts and to science was deep and sincere, and among many proofs of this may be particularly mentioned the valuable and essential services which he rendered to your late Honorary Member, Thomas Tredgold, both in his professional pursuits and in the prosecution and verification of his theories and calculations. Mr. Bramah being professionally engaged at Buckingham Palace, in connexion with some other engineers, difference in opinion existed and discussion arose, as to the true principle upon which the strength of cast-iron beams to resist stress and flexure ought to be estimated, and with the view of verifying the principles laid down by Tredgold, he instituted a very extended series of experiments, on the deflection and strength of cast-iron beams. These he presented to the Institution, and they are published in the second volume of your Transactions.

Several important works were executed under his direction, among which the iron work of the Waterloo Gallery at Windsor Castle; the cranes, the lock-gates, and their requisite machinery, at the St. Katherine's Docks; and the massive gates at Constitution Hill and Buckingham Palace, may be particularly mentioned. Mr. Bramah was an early and deeply-attached Member of this Institution; his constant attendance at the meetings, the information which he communicated, and his unwearied zeal as a Member of the Council, cannot be too highly estimated, and his loss will be deeply felt and regretted within these walls. The variety of his attainments, his refined taste in the arts, his amiable character and the warmth of his affections, had secured to him the respect and esteem of a most extensive circle of friends, by whom, as indeed by all in any way connected with him, his loss will be most deeply and sincerely felt.

Mr. Oldham.

John Oldham, the Engineer of the Banks of England and Ireland, was born in Dublin, where he served an apprenticeship to the business of an engraver, which he practised for some time, but subsequently quitted to become a miniature painter, wherein he acquired some reputation. He pursued this branch of the arts for many years, but having a strong bias towards mechanical pursuits, he devoted much of his leisure time to the acquisition of that knowledge which was to prove the foundation of his future celebrity. In the year 1812, he proposed to the Bank of Ireland his system of mechanical numbering and dating the notes, and on this being accepted, he became the chief Engraver and Engineer to that Establishment. The period of twenty-two years, during which he held this appointment, was marked by continually progressive steps of artistical and mechanical ingenuity. The various arrangements which he projected and carried out attracted great attention, and conferred considerable celebrity on the establishment with which he was connected.

The late Governor of the Bank of England, Mr. T. A. Curtis, had his attention directed to these important improvements, and under his influence the whole system of engraving and printing as pursued in the Bank of Ireland was introduced into the national establishment of this country, under the superintendence of its author, who continued in the service of the Bank until his death.

The ingenuity of Mr. Oldham was directed to other objects, especially to a system of ventilation, of which an account was given by the author during the session of 1837. Great versatility of inventive faculty, persevering industry, and social qualities of the highest order, were the prominent features in his character, and the success which attended his exertions is one of the many gratifying instances to be found in the history of this country, of talents and industry destitute of patronage attaining to eminence in the professions to which they are devoted.

Mr. Rowles.

Henry Rowles, the Chairman of the Rymney Iron Works, was educated in the office of his relative, Mr. H. Holland, the architect, on quitting which he entered into business as a builder. He was engaged among other extensive undertakings in building several of the East India Company's Warehouses, the Royal Mint, the Excise Office, and Drury Lane Theatre. He was an active Director in several Docks, Railway, and other Companies, and finally became Managing Director of the Rymney Iron Works, in the active discharge of the duties of which office he continued until his death. The Institution owes to him the Drawings of the Iron Works made by Mr. Richards.

Mr. Rickman.

John Rickman was educated at Lincoln College, Oxford, and graduated there; he subsequently devoted himself to literary pursuits, to political economy, and to practical mechanics. For some years he was conductor and principal contributor to the "Agricultural and Commercial Magazine." In 1801 he removed to Dublin, as Private Secretary to the Right Hon. Charles Abbot, then Keeper of his Majesty's Privy Seal in Ireland. Upon the election of Mr. Abbot to the Speaker's Chair in the House of Commons, Mr. Rickman continued to be his Private Secretary, and in 1814, he was appointed to the table of the House of Commons. He also acted as Secretary to the two Commissioners appointed by Act of Parliament in 1803, "for the making of Roads and Bridges in Scotland, and for the construction of the Caledonian Canal," and to the Commissioners "for building Churches in the Highlands." The ability and energy which he displayed in the discharge and conduct of the duties of these laborious offices, for more than thirty years, in addition to his constant attendance at the House of Commons, called forth the warmest acknowledgments of public meetings held in the Scotch counties on his retirement, and various resolutions were passed expressive of the sense entertained of the unremitting exertions, and uniform and disinterested assiduity, with which he had promoted every object connected with the improvement and general prosperity of the Highlands and Isles of Scotland. The conduct of the affairs of the Highland Commissioners brought Mr. Rickman into constant intercourse with their engineer, Mr. Telford; an intimate friendship was formed between them; and Mr. Rickman completed and published the account of the Life and Works of that eminent man, which was but partially arranged at the time of his decease.

Mr. Rickman's chief work is the Census of Great Britain, in six folio volumes; he is also the author of numerous papers connected with Statistics, having bestowed great pains in collecting and arranging the returns connected with education and local taxation. To this Institution he rendered very essential services, and whenever application was made to him in its behalf, was always zealous in endeavouring to promote its interests. The Library was enriched by him with two copies of the Life and Works of Telford, and as the acting executor of Telford, he endeavoured to carry out by every means in his power the intentions of that great benefactor of the Institution.

Mr. Rickman's acquirements in every department of knowledge were accurate and extensive; to great quickness of perception, and memory of no ordinary power, were added indefatigable industry, undeviating method, and a sound critical judgment;—qualities which caused his acquaintance to be highly valued by the most distinguished literary characters of the day, and which, no less than the strict and scrupulous sense of justice and honour, which particularly showed itself in his considerate kindness towards all those with whom he was connected, will occasion his loss to be deeply regretted by a widely extended circle.

Expenditure.

The account of the Receipt and Expenditure for the past year, shows the financial affairs of the Institution to be in a healthy state.

Dr.			
To Balance in the hands of the Treasurer ..	116	11	10
— Subscriptions and Fees	1509	8	2
— Dividends	68	8	10
— House Subscriptions	250	13	6
— Sale of Publications .	21	12	0
— House, Cannon Row, for Rent	100	0	0
— House, Great George Street, for Rent...	67	0	0
— Sale of Stock	298	15	2
	£2432	9	6

Cr.			
By House			
— No. 1, Cannon Row, for Rent, Taxes, Rates, and Repairs	82	1	10
— No. 25, Great George Street, on account of Alterations	550	0	0
— Ditto, for Rent, Taxes, Rates, Insurance, and Repairs	424	1	10
— Salaries & Commission	496	18	11
— Servant's Wages	83	8	6
— Postage and Parcels..	33	4	9
— Stationery & Engraving	37	15	6
— Coals, Oil, and Candles	54	1	6
— Tea and Coffee	41	4	1
— Library	30	0	5
— Publications.........	309	13	6
— Furniture	53	2	0
— Telford Premiums....	17	12	0
— Seals and Cases for Diplomas, engrossing them, sending Invitations, Letters, and Cards, repairing Models, Bankers' Clerks, Hanging Pictures, Pins for Drawings, occasional Assistance, and Household Utensils and Expenses...	36	14	0
— Balance.............	180	10	8
	£2432	9	6

The receipts are materially increased, and a large amount of accumulated debt has been paid off. Although the receipts have increased so much, there yet remains a larger amount of arrears than is usual to be collected: this has induced the Council to adopt the suggestion of a Member, in preparing orders upon Bankers and correspondents in London, which may be signed by those who would prefer it, to the present mode of collection, and it will save them and the Institution much trouble; they will be circulated very speedily among the Members generally. The expenditure for the alterations of the Premises of the Institution, 25, Great George Street, has borne heavily on its resources, and although the House Subscription has been liberal, the Council trust that it will be more general, to liquidate the debt of upwards of £300 still owing on account of the alterations. The book yet remains open for those Members who have not hitherto contributed, and Lists of the Subscribers are suspended in the Library and Reading Room of the Institution.

The Council found it expedient in order to diminish the amount of the debt on the buildings, to sell the Institution Funded Stock in the 3 per cent. Consols, but it is confidently hoped that, by the co-operation of Members in keeping up the interest of the meetings, and of the publications, such a state of prosperity may be arrived at as shall enable the funded property not only to be replaced, but very materially increased.

The Council have under consideration the propriety of establishing Special Meetings for the purpose of reading and illustrating Communications on subjects connected with the practice of Civil Engineering, and are disposed to accede to such applications as may be made to them, as far as they can do so consistently with the original objects of the Institution.

Conclusion. From this review of the past, the Council would now, in conclusion, direct your attention to the future, and remind you that, if the contemplation of the services and benefits thus conferred on the Institution do not stimulate all to similar exertions, one great object of this review will be lost. It is the duty of each succeeding Council, while it records what has been done, to point out also how much yet remains to be done, and to remind all those who are interested in the advancement of the Institution, that whatever may have already been achieved, ought only to be looked upon as an earnest of that which is to come.

The Council, in resigning into your hands the trust which has been confided to them, would congratulate the meeting on the proceedings of the past year, on the accession to the general body of many members distinguished for their attainments in various branches of knowledge, on the cordial co-operation and sympathy which has been received from all quarters, and on the success which has attended their endeavours to promote the best interests of the Institution.

TELFORD PREMIUMS.

The Council of the Institution of Civil Engineers have awarded the following Telford Premiums, for Communications received during the Session of 1840:—

A Telford Medal in Gold to Josiah Parkes, M. Inst. C. E., for his two papers "on Steam Boilers," and "on Steam Engines, principally with reference to their Consumption of Steam and Fuel," published in the 1st and 2nd Parts of Vol. III. of the Transactions.

A Telford Medal in silver, and Books suitably bound and inscribed, of the value of ten guineas, to James Leslie, M. Inst. C.E., for his "account of the Works of Dundee Harbour, with Plans and Drawings of the Works and the Machinery employed there."

A Telford Medal in silver, and Books suitably bound and inscribed, of the value of five guineas, to Robert Mallett, Assoc. Inst. C. E., for his paper "on the Corrosion of Cast and Wrought Iron in Water."

A Telford Medal in bronze, and Books suitably bound and inscribed, of the value of three guineas, to Charles Bourns, Assoc. Inst. C.E., for his paper "on Setting out Railway Curves."

A Telford Medal in Bronze, and Books suitably bound and inscribed, of the value of two guineas, to Henry Chapman, Grad. Inst. C.E., for his "Description and Drawings of a machine for describing the Profile of a Road."

A Telford Medal in bronze, and Books suitably bound and inscribed, of the value of two guineas, to Henry Renton, Grad. Inst. C.E., for his "Description and Drawing of a Self-acting Wasteboard on the River Ouse."

Books suitably bound and inscribed, of the value of five guineas, to Eugenius Birch, Grad. Inst. C.E., for his "Drawings and Description of the machine for Sewing Flat Ropes, in use at Huddart's Rope Manufactory."

Books suitably bound and inscribed, of the value of two guineas, to T. J. Maude, Grad. Inst. C.E., for his "Account of the Repairs and Alterations made in the Construction of the Menai Bridge, in consequence of the Gale of January 7th, 1839."

Books suitably bound and inscribed, of the value of two guineas, to Andrew Burn, Grad. Inst. C.E., for his "Drawings of a Proposed Suspension Bridge over the Haslar Lake."

The Council would take this opportunity of calling attention to the importance of making the Institution the depository of detailed Drawings, Descriptions, and Models of Works and Machinery actually executed; also of professional Books, Papers, and Reports, which are of little value to the individual, but which, when collected and arranged in one place, would be of inestimable value to the Profession. They trust that all who have such records at their disposal will consider the great service which may thus be rendered to the cause of the advancement of professional knowledge.

SUBJECTS FOR TELFORD PREMIUMS,
1841.

1. An Account and Drawings of the original construction and present state of the Plymouth Breakwater.
2. The alterations and improvements in Blackfriars Bridge.
3. The recent repairs to the Eddystone Lighthouse.
4. On the best Guage for the width of Railways, with the result of the experience of existing Railways.
5. On Stone Blocks and Timber Sleepers, or Sills, with and without continuous timber bearings, as foundations for Rails.
6. The ratio, from actual experiment, of the Velocity, Load, and Power, of Locomotive Engines on Railways, with the resistance to progressive motion at different velocities.
    1st. Upon Levels.
    2nd. Upon Inclined Planes.
7. A Statement of the Cost of Transport on Railways in Great Britain by Locomotive Engines, including the repairs, maintenance of way, and all incidental expenses.
8. Ditto by Stationary Engines, on levels or on inclined planes, including all repairs, maintenance of way, and incidental expenses, with Drawings and Description of the Engines and Machinery.
9. The causes of, and means of preventing, the Priming of Steam Boilers.

10. The quantity of water evaporated from Steam Boilers during experiments of not less than 12 hours' duration, if possible; including the consumption of fuel, its nature, the form and dimensions of the boilers and grates, the surfaces exposed to heat, their material and strength, and any other particulars.
11. The quantity or weight of Water consumed as Steam by any kind of Steam Engine, in the production of a definite effect; with an account and Drawings of the Engine, nature of the load, and methods employed to ascertain the absolute and useful effect of the Steam.
12. The best description of Meter for registering accurately the quantity of Water used for Steam Boilers, or other purposes.
13. The explosion of Steam Boilers; especially a record of facts connected with any explosions which have occurred: also, a description, drawings, and details, of the Boiler, both before and after the explosion.
14. Drawings, Sections, and Descriptions, of Iron Steam Vessels.
15. The comparative advantages of Iron and Wood as employed in the construction of Steam Vessels.
16. On the various kinds of Sheathing employed in the protection of Vessels, and their relative advantages.
17. Drawings and Descriptions of the Engines, Boilers, and general construction of Steam Vessels of the largest class, with a comparative tabular Statement of the dimensions of the principal parts of Engines of different powers, and their effect compared with that of smaller Engines.
18. On the use of high-pressure Steam on board Steam Vessels, with drawings and description of the Boilers.
19. On the best relative sizes of Steam Vessels of all classes in comparison with their Engine Power; illustrated by reference to Steam Vessels already constructed, and giving their size, tonnage, speed, consumption of fuel, &c.
20. On the best application of different kinds of fuel under the Boilers of Steam Engines, especially with reference to obtaining perfect combustion; illustrated by drawings of the Boilers.
21. On the application of the Screw to propelling Vessels, and a comparison between it and the common Paddles.
22. Common Sewers in cities: the rules for and details of their construction.
23. Drawings and Description of the Outfall of the King's Scholar's Pond Sewer.

24. Drawings and Descriptions of the Sewerage under the Commission for Regent Street, especially of the Outfall at Scotland Yard.
25. Plans and Sections of Blast Furnaces, with the necessary Mine Kilns, Hot-Blast Stoves, and general arrangement of an Iron Work, with a Description.
26. The comparative advantages and disadvantages of Hot and Cold Blast in the manufacture of Iron, with statements of the quality and quantity of materials employed, and produce thereof.
27. An Account of the various methods lately employed for preserving Timber from Dry Rot and other sources of decay; with the results of experience as to the kinds of Timber most applicable for Engineering works, and other situations where speedy destruction at present occurs.
28. A Memoir of Sir Hugh Middleton, with an Account of his Works.
29. A Memoir of Arthur Woolf, with an Account of his Works.
30. A Memoir of Jonathan Hornblower, with an Account of his Inventions and Works.
31. A Memoir of Richard Trevithick, with an Account of his Inventions and Works.
32. A Memoir of William Murdoch (of Soho) with an Account of his Inventions and Works.

The Communications must be forwarded to the House of the Institution, No. 25, Great George Street, Westminster, on or before the 31st of May, 1841.

It is not the wish of the Council to confine the TELFORD Premiums to communications on the above subjects; other communications of acknowledged merit, and peculiarly deserving some mark of distinction, will be rewarded.

ADDRESS OF THE PRESIDENT

TO THE

GENERAL MEETING,

FEBRUARY 2, 1841.

Allow me to thank you for the compliment you have again paid me, by electing me your President for this current year.

The Secretary has reminded me, that I have been in the habit of addressing you on occasions corresponding with the present, but the very full, and I believe I may say, satisfactory Report of your late Council, has left but little for me to say on the business of the Institution. Your new Council have elected Mr. Manby for Secretary, Mr. Gibbon for Collector, and Mr. Hankey for Treasurer. We have the test of long experience in favour of the Collector and Treasurer, and although our acquaintance with your Secretary is shorter in point of time, we are all convinced that his whole attention and energies will be, as indeed they hitherto have been, devoted to the Institution.

Hitherto the increased number of our Members, and the attendance at the meetings during each year, have been commensurate with the growing importance of the Institution, and I have little doubt of the success of the present Session being still greater. We have under consideration several interesting subjects, to which some of our most active Members have paid great attention, and in which they have made important discoveries—these will form the groundwork of interesting and instructive conversation, or even, to use the language of a greater assembly, of 'debate,' but I trust that our discussions will continue to be conducted, as heretofore, with that good temper which makes even *debate* delightful, when the attainment of truth is the sole object. Truth will not bend one inch out of its right line, to accommodate false theory. He who tells us, that he "lost his patience when works were censured not as bad but as new," might be a very good poet, but in this respect at least he was no philosopher. One of our Vice-Presidents has presented me, within a few days, with a Report on the best mode of improving one of our great navigable rivers: this Report contains observations tending to level with the dust much that has been said by, I believe, all other Engineers, on the importance of tidal back-water. I know from experience that many theories which have, through their novelty or otherwise, appeared startling on the first view, have proved to be founded on truth, and have therefore superseded the old-fashioned notions. No class of men can be more devoted or bigoted to their opinions, than the Aristotelian philosophers were to their doctrine of syllogisms and *a priori* theories, which, though it had the authority of ages and names, was obliged to yield to the once-despised and even persecuted inductive philosophy of Bacon. Although, therefore, some Engineers may not coincide with the views expressed by our Vice-President, we shall do much good by examining impartially into the deductions he has drawn, at the same time carefully avoiding all personal considerations. A distinguished English Essayist after remarking that nothing denotes a great mind more than the abhorrence of envy and detraction, states, that the best poets of the same age have always lived on terms of the greatest friendship; and surely if this is the case with poets, who draw much upon imagination, Engineers, who have to deal with science and with facts, have less apology for excited feelings.

Without seeking in the recollections of a bygone generation for comparisons, we may congratulate ourselves that, although the number of Engineers has much increased, we are, I trust, without exception, *friends;* and I consider that our intimacy has been materially assisted by this Institution, where we have met, compared opinions, and rubbed off the sharp angles of professional jealousy or emulation, if any such existed.

Another valuable Member of the Council has, he conceives, discovered the true theory of the action of steam in the Cornish Single Pumping Engines, by which he accounts for their extraordinary economy. This theory, which is equally novel and ingenious, is now subjected to your examination and criticism, and I am sure that my friend Mr. Parkes would feel disappointed if his discovery were not to be submitted to that ordeal, in common with every similar subject of importance which is brought under the notice of the Institution.

While I congratulate the Institution on the increase of its Members, I ought at the same time to express my opinion, that from the number of young gentlemen who within the last ten years have studied for, or have entered, the profession, the supply is likely to be at the least equal to the demand; and to caution those who intend entering or are now studying for it, against confining themselves to the strictly professional part of the usual routine of education.

The Railways, both during the preliminary surveys and in their subsequent construction and management, in addition to other works of Engineering, have given employment to many. But the principal towns are already connected by Railways, or Engineers and Surveyors are now employed in projecting or executing lines where they are yet wanted. Is then the demand for professional gentlemen likely to *increase?* Is it not likely rather to *decrease?* Now certainly the number of Engineers or Students for Engineering is increasing. If we look at the number of students in the classes for Civil Engineering at the different Universities and Academies; the Universities of Edinburgh and of Durham; King's College, University College, and the College for Civil Engineers in London; we are led to ask, will this country find employment for all these? I freely confess that I doubt it. My object in what I have here said is, not to deter those who may already have resolved and have taken measures to follow the profession, but to advise them not to depend on this country alone, and so to direct their studies as to fit them for other countries also, where the field is not large enough to support men who are strictly and exclusively professional. For such, great countries only can find employment, and other great countries are educating their own Engineers. To be fitted for going abroad to any part of the world, a man must be a tradesman as well as an Engineer; he must furnish his *hands* as well as his *head*—and if he know more trades than one, so much the better; for he may have to direct in *all,* but *one* he ought to know thoroughly. Thus stored, all the world is open to him, and with the formation of new continents and colonies, and the improvement in the old ones, the Engineer may insure independence. Not only in such countries, but at home also, his experience as a workman will prove his best friend and assistant in raising him to eminence, and make him feel that confidence in his own resources which has enabled so many Engineers, whose name and fame stand high in the annals of the profession, to raise themselves from the millwright, stone-mason, and carpenter, to the highest grade. As a strong corroboration of the system which I recommend, you will observe the practical education given by each of these individuals to those of their family who are intended to succeed them. Let it not be supposed that I would undervalue the importance of science or of a scientific education, which is as essential to the Engineer as the knowledge of the principles of navigation is to the naval officer, but that I earnestly recommend *practice* also.

I hope to be excused this digression, but the great number of young gentlemen who, having been bred in Engineers' offices, apply to me for employment, which I cannot give them, or to be admitted as apprentices when I cannot in justice receive them, makes me feel very sensibly the importance of these remarks, and that it is almost a duty to give this publicity to my opinion.

To return to the Institution: I hope the attendance at the ordinary Meetings will be even better than that of last Session—that the Secretary's list which is regularly posted up, will have still a greater number of bright spots and a smaller number of black marks opposite the names of the Council, as well as of the Members, Graduates, and Associates generally. I do not name this as a complaint, for the attendance has hitherto gone on improving, that of the Council influencing the Members.

I have lately referred to the very great, and I fear, increasing, number of debts due to the Institution from Members and Associates, and still more from Graduates who were elected under a promise to send in an original communication or drawing, and I hope that the present Session will show a great reduction in the amount of these engagements. The fear of not producing something of sufficient value operates probably to overcome the desire which every gentleman, having made a promise, must feel in redeeming it. As an encouragement, let me refer such persons to the contributions by Graduates during the last Session; they will find that some of them required little inventive genius, but only the ability to record correctly what they have noticed on the public works in which they have been engaged, or which they have visited. To some of these, the Council have awarded premiums, and they esteem them valuable as recording details of works taken from measurements at the time of execution, thus forming an addition to our records, and making the Institution a deposit of "*works done*," which is one of its important uses; and I think no Engineer intrusted with public works would prevent Graduates having the opportunity of doing this for their own improvement, and for the benefit of the Institution.

The subjects for these papers, models, and drawings, are numerous,—I may almost say, innumerable. Of many of the great national manufactures of this country we have as yet no records in our possession, and until we possess them our stores will be imperfect. As an Encyclopædia gives a definition and general description of every art, so should our Institution possess an original history, and drawings or models, as well as books, treating of every machine and manufacture connected with our profession.

Members of the Council during the last Session contributed liberally in books, and have set an example to the present Council. As a guide or specimen of the nature of the desired communications, the subjects for the Telford premiums have been varied and enlarged, but it is not to be understood that the subjects therein stated are to occupy exclusively the attention of Candidates, even for the Telford premiums. By thus enlarging the subjects and inviting papers, we may, I hope, look for an increased number of valuable communications, which it may press upon the Telford Fund to do justice to; I have therefore informed the Council that I have appropriated the interest of One Thousand Pounds, 3 per cent. Government securities, or Thirty Pounds per annum, which I request the Institution to accept, as my Annual Donation, to be applied as may appear best suited for the objects to which I have referred, or for other purposes conducive to the benefit of the Institution.

ORIGINAL COMMUNICATIONS.

Batson, Robert. On Samuel Hall's Patent Condensers, and their Application to the Engines of the British Queen. With two Drawings.

Bazalgette, J. W. Remarks on reclaiming Lands from the Sea; and Description of the projected Works on Loughs Swilly and Foyle. With seven Plans and Drawings.

Bell, Alexander. Description of an Expanding Mandrel for Lathes. With a Model.

Bourns, Charles. On setting out Curves on Lines of Railways. With Field Tables.

Brunel, M. I. On the actual State of the Thames Tunnel (June 23, 1840). With a Plan of the Works.

Burn, Andrew, Jun. Description of the proposed Suspension Bridge over the Haslar Lake at Portsmouth; and a copy of the Original Report on it by J. Bramah and Sons, July 1833. With four Drawings.

Carr, Henry. Description of a Levelling Machine, or Instrument for describing the Profile of Roads. With a Drawing.

Carr, Henry. Description of a Dynamometer, or an Instrument for measuring the Traction on Roads, Railways, Canals, &c. With a Drawing

Chapman, Henry. Description of a Machine for describing the Profile of a Road. With three Drawings.

Churchill, Mr. On a Specimen of White Cedar for Railway Sleepers, from Bathurst, New Brunswick.

Cowper, E. Description of an Azimuth Cap, as an addition to the Common Level. With a Drawing.

Cowper, E. Description of a Machine for detecting any variation in the Guage of a Railway. With a Model.

Cubitt, William. Description of a New System of covering Roofs with Planks. With a Model.

Cursetjee, Ardaseer. Remarks on the Engines of the Steam-Tug "Alice." With a Drawing of the Engines on board the Steam Boat "Staadt Frankfort."

Curtis, W. J. Description of a Bolster for Railways. With a Model.

Curtis, W. J. Description of a traversing Screw Jack. With a Model.

Davison, Robert. Description of a Refrigerator, or machine for Cooling Fluids. With two Drawings.

Delbruick, Monsieur. On the Autogenous uniting of Lead and other metals by means of a jet of flame of Hydrogen Gas and common Air.

Edwards, G. Description of a Patent Hinge for Doors. With a Model.

England, G. Description of a Screw Jack for replacing Locomotive Engines or Carriages on the rails after an Accident. With a Model.

Enys, Samuel. On the Stamping Engines in Cornwall. With four Drawings of the Carn Brae Engine, by Mr. Sims, jun.; presented to the Institution by Mr. Sims, sen.

Glynn, Joseph. On the use of Mica as a substitute for Glass in the windows of Workshops. With specimens of the Mica.

Gordon, Alexander. On Photography as applicable to Engineering.

Harper, Thomas. Description of a new Railway Chair. With a Model.

Harrison, John T. Description of a Levelling Machine, or Instrument for describing the Profile of a Road. With a Drawing.

Hartley, J. B. On the Effects of the Worm on Kyanized Timber exposed to the action of Sea Water, and on the Use of Greenheart Timber from Demerara, in the same situations. With a specimen of the Timber.

Hood, Charles. On the Properties and Chemical Constitution of Coal, with remarks on the methods of increasing its calorific Effect, and preventing the loss which occurs during its combustion.

Hood, Charles. On the Efflux of Gaseous Fluids under Pressure.

Kendall, Lieut. E. N., R.N. Description of the Steam Ship "India," with a new method of attaching the Shrouds by Iron

Hoses, and a Table of the Proportions and Scantling of large Steam Ships. With a Drawing by N. Walker, and a Model of the Shroud Hose.

Leslie, James. Description of a Crane calculated to lift 30 Tons, erected on the Quay of Earl Grey's Dock, Dundee, 1839. With three Drawings.

Lubbock, J. W. A theoretical Calculation of the Fuel saved by working Steam expansively.

Mallet, Robert. On the Corrosion of Cast and Wrought Iron in Water. With numerous Tables of results.

Mc Ewen, Robert. Description of an Apparatus for preventing the Explosion of Steam Boilers. With two Drawings.

Moorsom, Captain. Account of a series of Experiments on Locomotive Engines, more particularly on the "England," the "Columbia," and the "Atlantic," manufactured by Mr. Norris, of Philadelphia. With Tables of the results.

Murdoch, J. Description of a mode of disengaging the Paddle Shafts of Steam Vessels. With two Drawings.

Nasmyth, J. On a mode of bending discs of Silvered Plate Glass into Concave or Convex Mirrors, by means of the pressure of the Atmosphere. With a Pneumatic Mirror.

Parkes, Josiah. On the action of Steam in Cornish single Pumping Engines.

Patrick, S. Description of the Engines on board the Steam Tug "Alice." With two Drawings.

Pellatt, Apsley. On the Manufacture of Flint Glass. With numerous specimens.

Rickman, William. Description of the Earth-falls at the Undercliff, Isle of Wight.

Ryland, T. H. A Table of the Force required to draw out Screws of certain sizes from American Pine. With a collection of specimens of Screws used on various Railways.

Seaward, John. Description of the Engines on board the "Gorgon" and "Cyclops," Steam Frigates, with remarks on the comparative advantages of long and short connecting Rods, and long and short Stroke Engines. With a Drawing.

Williams, C. W. Description of the "Nonsuch," Passage Boat, plying on the Limerick Navigation, between that place and Killaloe. With a Model.

Woods, George. Remarks on the Experiments made by W. J. Henwood, relative to the power of the Huel Towan Steam Engine.

ORIGINAL DRAWINGS.

	DONORS.
Azimuth Cap, for a Common Level . .	Mr. Cowper.
Bridge, Suspension, proposed for the Haslar Lake, at Portsmouth . . .	Mr. Burn, Jun.
Crane, to lift 30 Tons, at Earl Grey's Dock, Dundee Harbour	Mr. Leslie.
Drawbridge over the Lock of the Salthouse Dock at Liverpool	Mr. J. B. Hartley.
Dynamometer, a, by a column of Mercury	Mr. Carr.
Engines, Marine, of the "British Queen"	Mr. Batson.
——————— on board the "Gorgon" and "Cyclops"	Mr. J. Seaward.
——————— of the Steam Boat "Staadt Frankfort"	Mr. Cursetjee.
Engines, Steam, on board the Steam Tug, "Alice"	Mr. Patrick.
——————— Locomotive (communicated by the President)	Mr. R. Dunn.
——————— Stamping at the Carn Brae Mines (communicated by Mr. Enys) .	Mr. Sims.
Gasometer, Patent Double, at the London Gas Works, Vauxhall	Mr. Hutchinson.
Loughs Swilly and Foyle, illustrative of Works in	Mr. Bazalgette.
Machine, Levelling, or Instrument for describing the profile of Roads . . .	Mr. Carr.
Ditto ditto . . .	Mr. Harrison.
Ditto ditto . . .	Mr. Chapman.
Paddle Shafts of Steam Vessels; mode of disengaging	Mr. Murdoch.
Propeller, Marine	Mr. Vint.
Refrigerator, or machine for Cooling Fluids	Mr. Davison.
Shrouds, new method of attaching, by Iron Hoses, on board the Steam Ship "India"	Lt. Kendall, R.N.
Steam Boilers, Apparatus for preventing the Explosion of	Mr. Mc Ewen.

CATALOGUE OF PRESENTS.

BOOKS.

TITLE OF BOOK.	DONORS.
Académie Royale des Sciences de Bruxelles, Bulletins, 1839. Tome 6, 1ère et 2nde parties	The Royal Academy of Brussels.
——— Annuaire. Idem. Sixième année .	
——— Nouveaux Mémoires. Idem. Tome XII.	
Address of the Marquis of Northampton, read at the Anniversary Meeting, Nov. 30, 1839. Pamp. 8vo. London, 1840	The Royal Society.
Aldrich, H. Elementa Architecturæ, civilis ad Vitruvii veterumque disciplinam et recentiorum præsertim à Palladii exempla probatiora concismata. 1 vol. 8vo. Oxonii, 1789	Mr Young.
——— Translation of the above by the Rev. P. Smith	
Amicus Curiæ. A Word to the Manufacturers of Great Britain on the Prospects of the Cotton Trade. Pamp. 8vo. London, 1840.	Mr. Manby, Sec.
Amicus Curiæ. Steam to India. Pamp. 8vo. London, 1840	
An Architect. Architectural Precedents; parts 1 to 7, 8vo. London, 1840 . . .	Mr. Williams.
Anderson, A. A Letter to the Directors of the projected East Indian Steam Navigation Company, containing a practical Exposition of the Prospects of that proposed undertaking, and of the real state of the question of Steam Communication with India. Pamp. 8vo. London, 1840 .	The Author.

TITLE OF BOOK	DONORS
Barlow, Peter. A Treatise on the Manufactures and Machinery of Great Britain. 4to. London, 1836.—To which is prefixed—Babbage, C. An Introductory View of the Principles of Manufactures, plates, 4to.	Col. Pasley, R.E.
Barlow's Tables of Squares, Cubes, Square Roots, Cube Roots, Reciprocals, of all Integer Numbers up to 10,000. 8vo. London, 1840	The Author.
Another Copy of ditto	Messrs. Taylor and Walton.
Barry, James. An Inquiry into the real and imaginary obstructions to the acquisition of the Arts in England. 8vo. London, 1775 . . . . Bell's New Pantheon. 4to. London, 1790	Mr. Young.
Bernard, C. E. An Essay on Arithmetical Perspective. 8vo. London, 1839 . .	Mr. Williams.
Bradley, Dr. Miscellaneous Works, and Correspondence. 4to. Oxford, 1832 . Supplement to ditto. Pamp. 4to. Oxford, 1833	Mr. Rigaud.
Brees, S. C. Railway Practice, 2nd Series, 4to. London, 1840 . . . . . ———— A Glossary of Civil Engineering. 8vo. London, 1840	The Author.
British Association. Report of the 9th Meeting of the British Association for the Advancement of Science. 8vo. London, 1840	The Association.
Britton, John. The History of the Houses of Parliament, at Westminster. 8vo. London, 1836	Mr. Howell.
———— An Account of the Parish Church of St. Pancras, London, with a Plan, Sections, and Views. Pamp. 4to. London, 1824	Mr. Britton.
Bruschetti, Giuseppe. Delle Machine locomotive é stazionarie ad uso di motare pei trasporti celeri sopra le vie di terra e di acqua in Lombardia. Pamp. 8vo. Milan, 1840	The Author.

TITLE OF BOOK	DONORS
Cautley, Capt. On the use of Wells in foundations as practised by the Natives of the Northern Doab. Pamp. Calcutta, 1839	The Author.
Challis, Rev. James. Astronomical Observations made at the Observatory of Cambridge, for the year 1838. Vol. XI. 4to. Cambridge, 1840	The Author.
Chappell, Capt. Reports relative to Smith's Patent Screw Propeller, as used on board the Archimedes Steam Vessel. Pamp. 8vo. London, 1840 . . .	The Author.
Clissold, S. A Letter to the Earl of Stradbroke, as to the expediency of improving the Harbour of Southwold by means of the River Blyth. Pamp. 8vo. Halesworth, 1840.	Mr. Walker, President.
Copeland, Captain, R. N. An Introduction to the Practice of Nautical Surveying and the construction of Sea Charts. 4to. London, 1823	Mr. Young.
Crane *v.* Price. Report of the trial in the Court of Common Pleas, Feb. 11, 1840. (On the manufacture of Iron with Anthracite Coal.) Folio. London, 1840	Mr. Crane.
Daniell, J. F. An Introduction to the Study of Chemical Philosophy. 8vo. London, 1839	Col. Pasley, R.E.
Davy, Sir H. On the Safety Lamp for Coal Miners, with some researches on Flame. 8vo. London, 1818 . .	Mr. Young.
De la Bèche. Geological Manual, 8vo.	Mr. Wicksteed.
Demonceau, M. Rapport sur l'examen du projèt de loi autorisant le Gouvernement à contracter un emprunt de 90 millions de francs pour les Travaux Publics. Folio sheet. Brussels, 1840 . . .	M. Simons, by order of His Excellency the Minister of Public Works of Belgium.

TITLE OF BOOK	DONORS
Denham, Captain, R.N. Sailing Directions for the Rivers Dee and Mersey, with Charts. 8vo. Liverpool, 1840 . .	The Author.
Denison, Lieut. Professional Papers on Subjects connected with the duties of the Corps of Royal Engineers. Vol. III. 4to. London, 1839	The Editor.
Desaguliers, J. T. A Course of Experimental Philosophy. 2 vols. 4to. London, 1763	Mr. Young.
Donaldson, T. L. A Treatise on Lime, Mortar, Stucco, and Cement, being the article "Stucco" in the Encyclopedia Metropolitana, 4to. London, 1840 . . .	The Author.
Dumont, A. H. Mémoire sur la constitution Géologique de la province de Liège. Brussels, 1832. 4to. Plans . .	Mr. Manby, Sec.
Dupin, Baron Charles. Rapport fait à la Chambre des Paris relatif au travail des enfans dans les Manufactures. Pamp. 8vo. Paris, 1840	The Author.
Edye, John. Calculations relating to the Equipment, Displacement, &c., of Ships and Vessels of War. Large 8vo. London, 1832	Mr. Clegram.
Evans, Richard. A Report upon the Strength and other Properties of Anthracite Pig Iron. Pamp. 8vo. Manchester, 1840.	The Author.
Franklin, Dr. Miscellaneous Works of, 3 vols. 8vo. London, 1806 . . .	Mr. Lowe.
———— Experiments and Observations on Electricity made at Philadelphia, 4to. London, 1769	Mr. Young.
Flachat and Petiet. Guide du Mécanicien Conducteur de Machines Locomotives. 12mo. Paris, 1840 . . .	The Authors.
———— Calculs et Tableaux sur l'avance du Tiroir, les Tuyaux d'échappement, les conduits de Vapeur et de fumée dans les Machines Locomotives . . .	Mr. Manby, Sec.

TITLE OF BOOK	DONORS
Gilbert, Davies. On the expediency of assigning specific names to all such functions of simple Elements as represent definite Physical Properties, with the suggestion of a new Term in Mechanics. Pamp. 4to. London, 1827 . . .	Mr. Enys.
——— ——— On the Regular or Platonic Solids. Pamp. 8vo. London, 1828.	
——— ——— An Investigation of the methods used for approximating to the Roots of affected Equations. Pamp. 8vo. London	
——— ——— On some properties of the Catenarian Curve. Pamp. 8vo. London	
——— ——— On Wheels and Springs for Carriages, the draft of Cattle, and the form of Roads. Pamp. 8vo. London .	
——— ——— On the Ventilation of Rooms, and on the ascent of heated Gases through Flues. Pamp. 8vo. London . .	
——— ——— A plain Statement of the Bullion Question. Pamp. 8vo. London, 1819	
——— ——— On the progressive improvements made in the efficiency of Steam Engines in Cornwall. Pamp. 4to. London, 1830	
——— ——— On the Nature of Negative and of Imaginary Quantities. Pamp. 4to. London, 1831	
——— ——— Tables for Suspension Bridges. Pamp. 8vo. London	
——— ——— On the Mathematical Theory of Suspension Bridges, with Tables for facilitating their construction. Pamp. 4to. London, 1826	
——— ——— A Table facilitating the computations relative to Suspension Bridges. Pamp. 4to. London, 1831 . . .	

TITLE OF BOOK	DONORS
Gilbert, Davies. On the vibrations of heavy bodies, in cycloidal and in circular arches, as compared with their descents through free space, including an estimate of the variable circular excess in vibrations continually decreasing. Pamp. 8vo. London	Mr. Enys.
——————— Addresses to the Royal Society at the Anniversary Meetings in the Years 1827, 1828, and 1830. Pamps. London	
Godson, R. A Treatise on the Law of Patents. 8vo. London, 1823 . .	Mr. Collinge.
Gravesande, W. Mathematical Elements of Natural Philosophy, translated by J. T. Desaguliers. 2 vols. 4to. 1747 . .	Mr. Young.
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INSTITUTION

OF

CIVIL ENGINEERS.

SESSION 1841.

Jan. 12, 1841.

JOSHUA FIELD, V. P., in the Chair.

"Remarks on the comparative advantages of long and short Connecting Rods, and long and short stroke Engines." By John Seaward, M. Inst. C. E.

Gorgon Engines.

The author commences the communication with a description of the engines first placed on board the Steam Frigate, "The Gorgon."

The engines are constructed on the principle of "direct action," that is, the power is communicated directly from the piston to the crank, without the intervention of side levers, and the other parts usually employed in the construction of marine engines; this is one leading feature. Another is, that the main shafts are placed directly over the centre of the cylinder; and as these shafts are carried by strong frames and wrought-iron columns standing upon the cylinders, the force of the engines is confined between the cylinders and the frame, and thus isolated from the sides of the vessel. Other advantages accruing from this construction are, in the author's opinion, a saving of space and weight, the absence of the vibration resulting from the action of the side levers, and a more efficient application of motive power, arising from the simplicity of the construction and diminution of friction.

Two main objections have been urged against this system—1st, that the shortness of the connecting rod causes a loss of effect; and

2nd, that the shortness of the stroke is a disadvantageous application of the power of steam.

Long and short connecting rods.

The arguments in support of these objections are combated at considerable length. With reference to the alleged loss of power by the use of the short connecting rod, it is argued, that as no arrangement of long or short rods or levers could create power; so no arrangement of similar parts could be productive of loss of power. A geometrical investigation of the force actually exerted on the crank by long and short connecting rods is then given, and the result deduced is, that by adding together the whole of the force exerted by the two kinds of connecting rods respectively, during one entire rotation, they both give the same actual amount; thus proving, that no loss arises from the use of the short connecting rod.

It is admitted, that there is some increase of friction on the journals of the connecting rod joints, but this occurs only at the extreme angles; some allowance is also to be made for the increased angular motion about the lower joints of the rod, but they are not collectively of sufficient importance to be considered as any objection in practice.

The calculations given are under the approval of Professor Airy, who thus expresses himself:—" The *greatest* force of the ' Gorgon' engines (when both cranks are below the horizontal line) is *greater* than the *greatest* force with common engines, but the *least* force is not less than the *least* force with common engines."

The whole power, in a complete revolution of the crank, is the same in both.

That a long stroke engine, under certain circumstances, may be more advantageously employed than a short one, is admitted; but considering the steam engine *per se*, it is argued, that the latter possesses no advantage over the former.

In two engines of equal power, equally well constructed, the length of the stroke being respectively eight feet and four feet, the cylinder of the latter having double the area of that of the former, making the same number of revolutions per minute, and having the steam passages and valves of the same area, it is clear, that the mechanical action of the steam must be identical, because the same volume of steam will produce an equal mechanical effect, whether it be introduced into a long narrow cylinder, or into a short wide one; setting aside the effect of working expansively, which, however, is not at all affected by the shortening of the cylinder: for it is just as practicable to shut off the steam at one-half, one-third, or one-fourth of the stroke of a short cylinder as of a long one.

The most essential differences between these two engines must be in the relative amount of friction, and of radiation of heat from the cylinders and passages.

Friction. In a well-made engine four-fifths of the friction is due to the packings of the piston, air-pump bucket, and stuffing boxes, and about one-fifth to the gudgeons, crank pin, and other moving parts. The friction of the piston packing is as the circumference multiplied into the space through which the piston travels, and into the depth of the packing; therefore in a cylinder 30 inches diameter, 8 feet long, the friction of the packing will be as 24. while in a cylinder of 42·4 inches in diameter, 4 feet long, it will be only as 17.

The same train of reasoning is extended to the other moving parts, and shows that if the total friction in the short stroke be 100, that of the long stroke engine will be 123.

The radiation of heat from the cylinders will be as the relative areas of surface, which is less in the short stroke than in the long.

An examination of the comparative friction of the moving parts of steam engines is entered into; rules for computing, and tabular results are given; and the author concludes by observing, that although the relative dimensions selected as examples are uncommon in England, they are not so in America, where pistons of marine engines frequently travel at the rate of three hundred to four hundred feet per minute. It is contended that the speed of the piston is immaterial, provided the engine be well-proportioned to the speed; at the same time bearing in mind that a slow speed will be more favourable for the easy and pleasant working of the engine, and for durability. The paramount objects to be aimed at in the construction of marine engines are, the greatest saving of fuel, space, and weight, and the durability of the machine; and as the question is not whether the stroke should be eight feet or four feet, but relates to a diminution from the present length of seven feet to probably six feet, it is contended that the form of the "Gorgon" engines offers considerable advantages in the points treated of, independently of the positive diminution of weight and space, which forms no part of the immediate inquiry.

A drawing of the "Gorgon" engines accompanied the communication.

"Description of a Thirty-Ton Crane, erected on the Quay of Earl Grey's Dock, Dundee Harbour." By James Leslie, M. Inst. C. E.

30-Ton Crane. The Crane is placed on a stone platform sixteen feet square, raised six feet above the level of the Quay, with its centre seven feet back from the Dock face; and as the sweep or radius is thirty-five feet to the perpendicular of the jib-sheave, the load is suspended twenty-eight or twenty-nine feet over the Dock (as the double or single purchase sheave is used). The height of the sheave above the level of the Quay is forty feet.

Instead of the framing revolving about a fixed post, as in the usual mode of construction, the post itself is connected with the framing, and turns with it, so that the strain may be always in the direction of the greatest strength.

To avoid the extra dimensions of the castings for the post, if it had been composed entirely of cast iron, and for facility in the construction, the parts of cast and wrought iron are so combined that the "push" is thrown upon the cast-iron abutting piece which is placed in front, while the back part, consisting of wrought-iron tension bars, bears the "pull." The two rings on the post are turned on the face and edges, and being bolted together form a fair surface for the friction rollers, while the back forms a rest for the tension bars.

These back tension bars are three inches wide by two and a half inches thick, each, forming an aggregate section of forty-five inches. They were all proved in the bent form in which they are used, by making fast the ends of each bar to cross heads held apart by two logs, and suspending a load of twenty-four tons from the elbow formed by the bend in the bar; this was calculated to be equivalent to a longitudinal strain of ninety tons. There are also two side tension bars, two inches square each, firmly sunk in the cast-iron block, and bolted to the top of the framing.

The post revolves within a cast-iron cylinder twenty-seven feet deep, five feet three inches diameter, with turned and bored water-tight joints. The whole is surrounded with masonry, bound together by strong iron hoops and diagonal tie bars passing through the fixed ring.

The jib is of oak two feet diameter in the middle, and twenty-one inches at the ends; the two wrought-iron jib stays are each three and a half inches diameter; the chain is of $1\frac{1}{4}$ inch iron. Eight men easily lift a weight of thirty tons, and by means of the horizontal wheel-work one man can turn it round.

The total weight of the castings, wrought-iron bars, chain, and brasses, is about fifty-nine tons.

The crane was made and erected by Mr. Borrie, of Dundee, from the designs and under the direction of the author.

The communication is accompanied by two elaborate working drawings, on a large scale, with details of the mode of construction.

"A Refrigerator, or Machine for cooling Brewers' Wort." By Robert Davison, M. Inst. C. E.

Refrigerator.

The machine described in this paper was constructed for the purpose of ascertaining the most expeditious process for cooling wort, without deteriorating the quality of the liquor.

Two kinds of preliminary experiments were made, viz.—

1st. As to the rate of cooling by simple exposure to the atmosphere in the ordinary shallow vessel, having a superficial area of 420 square inches, the liquor being 1½ inch deep.

2d. As to the rate of cooling, under similar circumstances, with the assistance of air mechanically driven over the surface of the liquor at different velocities.

In both cases the loss by evaporation was noted.

The numerous experiments are detailed in a tabular form, whence may be selected three series, which will give the average relative results.

Wort cooled.	Naturally, under Atmospheric Temperature, 75°		1. By Blast at the rate of 32 miles per hour. Temp. 65°		2. Blast at the rate of 47 miles per hour. Temp. 65°		3. Blast at the rate of 57 miles per hour. Temp. 65°		4. Blast at the rate of 84½ miles per hour. Temp. 65°	
	min.	sec.	min.	sec.	min.	sec.	min.	sec.	min.	sec.
From 160° to 150°	3	33	2	,,	1	30	,,	41	,,	25
From 130° to 120°	8	30	1	10	2	4	1	6	1	7
From 100° to 90°	22	5	6	30	3	41	3	18	2	3

A higher velocity than 84½ miles per hour was found prejudicial, as a portion of the wort was driven over the side of the vessel.

The relative loss by evaporation was

By natural cooling	1·40
By blast, at 32 miles per hour . . .	1·45
Ditto at 57 miles	1·47

Hence it would appear, that the evaporation effected was about the same in all the experiments; and the rate of refrigeration nearly in the direct ratio of the velocity of blast.

These results induced the author to try other applications of the blast, by causing the wort to flow down over a series of slightly inclined planes, being exposed at the same time to a powerful ascending current of air from a fan blower. The introduction of air directly into the wort was, however, found to raise a froth or "fob," which would affect the soundness of the beer. Several other methods were tried, and at length the machine now described was constructed.

The wort is pumped up at a slow and regulated speed into a recipient at the top of the machine, divides into a series of thin films or streams, and trickles down the inside of a number of thin metallic tubes, set vertically, with their upper extremities quite level. Up these tubes is forced a current of air at any required velocity, which, meeting the descending wort, cools it inside, whilst a constant change of cold water takes place around the exterior of the tubes. The wort, on leaving the vertical tubes, is received into a second refrigerator, containing a number of horizontal pipes through which cold water flows. By this process the wort is cooled without producing any prejudicial effect upon its quality, and with a rapidity (as shown by the table) which would be extremely advantageous under certain circumstances.

This communication was accompanied by two drawings of the Refrigerator, and illustrated by a working model with which the experiments had been made.

"An Account of the Repairs and Alterations made in the Structure of the Menai Bridge, in consequence of the damage it received during the gale of January 7, 1839." By T. J. Maude, Grad. Inst. C. E.

Menai Bridge.

The roadway of the Menai Bridge having been seriously injured by the storm of January 7, 1839, it was deemed expedient to renew entirely the suspended platform: and at the same time to carry into effect certain alterations in the construction, suggested by constant observation of the working of the Bridge during thirteen years, as well as its condition after the storm.

Roadway Bearers.

In the original structure, each long roadway bar was fixed at three points to the vertical suspending rods. Motion being chiefly communicated to the roadway by the vibration of the windward chain, one end of the long bar suspended from it was lifted up, whilst the other two points of suspension remained nearly stationary. The bar thus became a lever with its fulcrum at the middle point of attachment, and at that weakest part it invariably broke. In order to remedy this defect, an augmented depth of half an inch has been given to the new roadway bars, with an additional enlargement round the eyes for attachment to the suspension rods, and each bar is hung from two points only, permitting it to play when the Bridge is subjected to motion.

Suspension Rods.

The same vibratory action occasioned frequent fracture of the suspending rods close to the surface of the platform; to such an extent, that during the storm a great portion of the platform was entirely torn from its fastenings on one side, and hung down flapping in the gale supported merely by one line of rods. To remedy this, a joint has been introduced in each rod just above the surface of the platform, so as to allow the suspension rods free action, and permit a motion in either of the carriage-ways or the footpath independently of each other. The dimensions of the short suspension rods have been increased to one inch and a quarter square, whilst the remainder of the rods are only one inch square. The effects of the lateral and undulating motions are provided against by the direction of the working of the joints, one of them being in the line of the roadway bar, and the other at right angles to it.

Platform.

Additional rigidity has been given to the platform by applying a course of three-inch planking laid transversely throughout its entire length, and bolted through each plank at intervals of two feet six inches apart, the oak beams originally placed beneath the platform having been entirely removed.

Undulation.

For the purpose of checking longitudinal undulation, two lines of beams, formed of two pieces of Baltic fir, each 40 feet long, 13 inches deep, and $4\frac{1}{4}$ inches thick, are framed to the trussed bearers, and bolted up beneath each carriage-way the entire length of the platform: at the same time an increased depth has been given to the wheel guides, which are also bolted through to the planking. The total depth given by these strengthening beams and guides, is three feet four inches, while in the original structure it was one foot four inches.

The weight of the additional timber and iron-work introduced into the bridge, is about 130 tons. The whole of the timber has been Kyanized, and each coat of planking covered with Archangel tar; the felt has been discarded, as it does not appear to have answered its intended objects in the original structure.

In these alterations (which were designed by Mr. Provis, M. Inst. C. E.) one main object, which was never lost sight of, was to preserve that simplicity of construction which is so striking a feature in the original design; and should any future derangements occur, any part can be repaired or replaced without disturbing the rest of the structure.

This communication was illustrated by a drawing of the original platform, and of the alterations described in the Paper.

February 2, 1841.

The PRESIDENT in the Chair.

"On a Method of setting out involute Teeth of Wheels, so that any two wheels of the same or of different diameters will work truly together, whether the teeth bottom or only just touch each other." By Edward Cowper.

The rule is briefly this:—

Teeth of Wheels.

Point off the teeth on the pitch circle in the usual manner; then take the smallest wheel of the set, and having decided upon the depth of the proposed tooth, describe a circle (called the Evolute) touching the bottom of the tooth. On all the other wheels describe evolute circles, bearing the same proportion to *their* respective pitch circles, which the evolute circle of the smallest wheel bears to *its* pitch circle—thus, if in the smallest wheel the evolute circle is $\frac{1}{12}$th less than the pitch circle, let all the other evolutes be $\frac{1}{12}$th less than *their* pitch circles. From these evolute circles as bases, describe the involute curves of the teeth, making the curves pass through the points set out for the teeth, upon the pitch line.

"An Account of some Experiments to determine the force necessary to punch holes through plates of wrought iron and copper." By Joseph Colthurst.

Punching Iron and Copper.

These experiments were performed with a cast-iron lever, 11 feet long, multiplying the strain ten times, with a screw adjustment at the head, and a counterpoise.

The sheets of iron and copper which were experimented upon were placed between two perforated steel plates, and the punch, the nipple of which was perfectly flat on the face, being inserted into a hole in the upper plate, was driven through by the pressure of the lever.

The average results of the several experiments (which are given in a detailed tabular form) show that

	Inch diam		Inch thick.	
The power required to force a punch	0·50	Through an iron plate	0·08	is 6025 lbs.
Ditto	0·50	Ditto	0·17	is 11,950 lbs.
Ditto	0·50	Ditto	0·24	is 17,100 lbs.
Ditto	0·50	Through a copper plate	0·08	is 3983 lbs.
Ditto	0·50	Ditto	0·17	is 7883 lbs.

Hence it is evident, that the force necessary to punch holes of different diameters through metal of various thicknesses, is directly as the diameter of the holes and the thickness of the metal.

A simple rule for determining the force required for punching, may be thus deduced.

Constant Number.

Taking one inch diameter, and one inch in thickness, as the units of calculation, it is shown that 150,000 is the constant number for wrought-iron plates, and 96,000 for copper plates.

Formula.

Multiply the constant number by the given diameter in inches, and by the thickness in inches; the product is the pressure in pounds, which will be required to punch a hole of a given diameter, through a plate of a given thickness.

It was observed, that duration of pressure lessened considerably the ultimate force necessary to punch through metal, and that the use of oil on the punch reduced the pressure about eight per cent.

A drawing of the experimental lever and apparatus accompanied the communication.

Mr. Sopwith. Geological Sections of Railway Cuttings.

Mr. Sopwith called the attention of the meeting to the valuable Geological Sections presented by the railway cuttings, and other engineering works now in progress; this was particularly the case on the North Midland Railway, where the crops of the various seams of coal, with the interposing strata, were displayed in the clearest manner, developing the geological structure of the country which the railway traverses. Numerous similar instances induced the British Association to devote a sum of £200. (which it was believed would be increased from other sources), for obtaining authentic records of such sections, before the action of the atmosphere or the progress of vegetation should have obliterated the instructive pages of geology, which the engineer had opened to view.

The Committee of the British Association, especially charged with this subject, were desirous of bringing it before the Institution of Civil Engineers, for the double purpose of receiving from its Members those suggestions which they are so competent to give, and of obtaining from them that powerful aid and co-operation which the practical nature of their engagements so essentially enabled them to afford; it was accordingly suggested, that the Council should receive from Graduates, descriptive papers and measured delineations of sections, as their communications previously to their Election. Much assistance might thus be rendered, and the contributions, after having been read at the Institution, might be added to the general series preserved in the Museum of Economic Geology, which under its present able direction is becoming daily more interesting both to the engineer and the geologist.

Charts. Mr. Sopwith exhibited a specimen of a blank chart, prepared by Mr. Phillips, of York, for the committee. It consisted of a sheet engraved in squares, on a scale of 40 feet to an inch, containing a space equivalent to 800 feet in length, and 600 feet in height, upon which it was proposed to delineate the sections, in their true vertical and horizontal proportions; the base line representing either the level of the sea at half tide, or the datum line of the railway, as might be most convenient. There would remain in every case a large portion of the sheet unoccupied by the section, and upon this it was proposed to exhibit, on a magnified scale, the details of the section; the fossils and other organic remains might also be shown, as the divisions of the squares would enable the sketches to be made of any dimensions in correct proportions. An example of these charts had been prepared by Mr. Phillips, giving a section of a deep cutting on a railway, the enlarged portion exhibiting the details of the strata at two particularly interesting points, as also of the specimens of sigillaria, stigmaria, &c. in that formation.*

Geological Models. Mr. Sopwith also laid before the meeting a set of models, which were intended as hand specimens for the purpose of familiarly explaining faults, slips, or dislocations of the strata, and other geological phenomena, which could not be clearly demonstrated without such assistance. One of these models represented the horizontal deposition of stratified rocks, and the subsequent removal or degradation of such rocks, forming valleys of denudation. Another, by the displacement of the lower rocks, exhibited the formation of a slip dyke, or fault, which was the "lode or vein" of the mineral miner, and the "fault" or "trouble" of the collier, as these interruptions of the continuity of the bed of coal were generally termed. Another model showed a succession of slip dykes disturbing the stratification, so as to present the appearance of a great abundance of coal at the surface by the "cropping out" or "bassetting" of a number of seams or beds of coal, whereas in reality there was only a repetition of the same beds. By examining the base of the model, and also by opening it on an oblique plane nearly parallel with, and at a short distance below, the surface, it would be found that there was no coal at all. A fourth model exhibited the conditions under which some of the largest collieries in the kingdom are worked, namely, that the seams of coal do not appear on the surface, but on opening the model a vertical section is exhibited, and the several beds are shown, disturbed as in the former case by faults or dislocations, but which have not the effect of bringing the coal to the surface.

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* Specimens of the prepared Sections and blank Charts may be obtained from Mr. Delabèche or Mr. Jordan, at the Museum of Economic Geology, Craig's Court, Charing Cross, or from the Secretary of the Institution of Civil Engineers.

It has always been difficult to demonstrate without the aid of models the apparent form of strata, as effected by the contour of the country; sometimes the rocks form a V, pointing up the valley, and sometimes in the opposite direction. General observers and even practical miners were apt to conclude, that this different direction of the point of the V, indicated a different direction of the strata, but the models showed that in both cases the direction of the strata was the same; that in both cases the rocks were inclined in the same direction as the valley, the only difference being that in one case the rocks form a greater, and in the other a less, angle with the horizon than the bottom of the valley. The other models exhibited the "up-cast" and "down-cast" which occur in coal mining, and intersections of veins of different ages, &c. &c. Most of the specimens shown presented details of the carboniferous formation, but models of this description were of course applicable to every formation and to every kind of geological structure. Mr. Sopwith brought forward this subject in hopes that eventually a close union and active co-operation might be established between the leading scientific institutions of this country, and more especially that the Geological Society and the Institution of Civil Engineers would unite in promoting the progress and improvement of geology and engineering.

February 9, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: Sir Charles Baird, as a Member; Samuel Beazley, William Gossage, John Hughes, John Howkins, and Charles Schafaeutl, M.D., as Associates.

"Upon the Application and Use of Auxiliary Steam Power, for the purpose of shortening the time occupied by Sailing Ships upon distant voyages." By Samuel Seaward, M. Inst. C. E.

Auxiliary Steam Power.

But few years have elapsed since the possibility of propelling vessels by the power of steam was treated as a chimera; and although the practicability of its application for short voyages has been successfully demonstrated by the numerous vessels plying between this country and the Continent, it is but of very recent date that its employment for long sea voyages has been adopted. The weight of the powerful machinery and the fuel, and the consequent loss of space for cargo, together with many other circumstances attendant on the present construction of steam vessels, induced the author (who received the education of a seaman, and has since had extensive practice as an engineer) to believe that a more efficient mode of employing steam power for long sea voyages might be adopted.

Limited duration of Steam voyages.

Notwithstanding the great improvements which have taken place in the construction of steam vessels, and their machinery, it would appear that the duration of the voyage ought not to exceed twenty days, after which time a fresh supply of fuel becomes necessary; hence, steam has rarely been adopted for very long voyages. The reason of this limit to the duration of the voyage of a steam vessel, as at present equipped, is that an increase of power does not produce a corresponding increase of speed, while the weight of the machinery increases in proportion to the power employed, and in some cases exceeds it; for instance, small engines, with the water in the boilers, generally weigh about one ton per horse power, while in some large engines the ratio is nearly twenty-five cwt. per horse power.

Power and Velocity.

A quadruple increase of power will not produce double the original velocity in a steam ship, although, in theory, such is assumed to be the case; for as the weight is more than doubled, the immersed sectional area becomes greater, and a still further increase of power is necessary. It has been shown by experience, that if a vessel with a given power is propelled through the water at the rate of eight miles per hour, her speed cannot be doubled, even though the power be multiplied twelve times, and the entire hold of the vessel occupied as an engine room.

Weight of Engines and Fuel.

The weight of fuel is also in direct proportion to the size of the engines; so that taking, for example, two vessels of two hundred and of four hundred horses power respectively—that of the higher power will have to carry nearly double the weight both of fuel and of engines, and it is still questionable whether the increased force will propel the one ship more than 1½ mile per hour faster than the other.

The space occupied by the engines and fuel in the most valuable part of the ship, is also an important consideration: neither the "President" nor "British Queen" steamer, although of two thousand tons measurement, is capable of carrying more than five hundred tons of cargo when the fuel is on board.

The 'Liverpool.'

The author then examines the question of employing too much power in a steam vessel, and refers to the "Liverpool," as an instance that such may be the fact. It appears that with the original dimensions of thirty feet ten inches beam, and engine power of four hundred and fifty horses, being a proportion of power to tonnage of about 1 to $2\frac{1}{4}$, the vessel was immersed four feet beyond the calculated water line, and a decided failure was the natural consequence; but when the breadth of beam was increased to thirty-seven feet, augmenting the capacity four hundred tons, and giving the proportion of one horse power to $3\frac{3}{4}$ tons burthen, the performance of the engine and the speed of the vessel were both materially improved.

The 'Gem' and the 'Ruby.'

The "Gem," Gravesend steamer, one hundred and forty-five feet long, by nineteen feet beam, had two engines of fifty horses power each; the speed was insufficient, being only twelve and a half miles through the water; but when the same engines were placed in the "Ruby," which was one hundred and fifty feet long, and nineteen feet nine inches beam, the velocity of the latter vessel was thirteen and a half miles per hour. A pair of engines, of forty-five horses power each, were then placed in the "Gem," without altering the vessel, and in consequence of the diminished weight and draught of water, her speed then nearly equalled that of the "Ruby."

The author does not condemn the application of considerable power for vessels, provided it can be employed without materially increasing the weight and the area of the immersed midship section. It appears that the length of a steam voyage, to be profitable, is at present limited to twenty days for the largest class of steamers; that we have about thirty others which can approach twelve days, while the majority cannot employ steam beyond eight days successively, without a fresh supply of fuel. It is evident, therefore, that more efficient means must be adopted for the general wants of commerce in our extended intercourse with the East and West Indies, the Pacific, Mexico, Brazil, Australia, and all the distant colonies, which now demand rapid communication with England.

The author refers to a pamphlet, published by him in 1827, entitled, "Observations on the possibility of successfully employing Steam Power in navigating Ships between this country and the East Indies by the Cape of Good Hope." He therein proposed that large square-rigged ships, of fifteen hundred to eighteen hundred tons measurement, should be fully equipped and constructed, so as to sail ten or eleven miles per hour with a fair wind; that they should carry engines of small power, to assist the sails in light winds, propel them at a moderate speed during calms, work into and out of harbour, &c., and thus shorten those portions of the voyages wherein so much time was usually lost.

Application of small power.

To all well-built good-sailing vessels, of four hundred tons and upwards, "auxiliary steam" is applicable. A steam engine of the necessary power can without inconvenience be placed in such vessels, either on or between decks, so as to propel a ship at the rate of four to five nautical miles per hour in a calm, and for this speed a proportion of one horse power to twenty-five tons is amply sufficient. The practicability of applying this system to East Indiamen and other similar vessels is then examined at length, and it is shewn that the ordinary speed of these ships under sail is, before the wind, eleven to twelve miles per hour, and in a gale thirteen to fourteen miles per hour, which is greater by two or three miles per hour than that of any ordinary steam vessel when under sail, on account of the latter being impeded by the wheels trailing in the water, and the slightness of their masts, spars, and rigging. The auxiliary steam power might, therefore, be efficiently applied, either by using it alone, or in conjunction with the sails, so as to keep up a uniform speed, by which a great saving of time could be effected in a long voyage.

The conditions of sailing and steaming voyages to India, with the influence of the trade-winds, are then examined, and the author proceeds to detail the experiments made by him, on board the "Vernon" Indiaman, which was the first sailing vessel that actually made a voyage out and home with "auxiliary steam."

The 'Vernon.'

The "Vernon," built in 1839, by the owner, Mr. Green, was one thousand tons burthen; the sailing speed was about twelve to thirteen miles per hour in a fresh gale, and being from her frigate build well calculated for the experiment, it was determined to equip her with a condensing engine of thirty horses power, placed midships on the main deck, between the fore and main hatchways; the space occupied being twenty-four feet long by ten wide. The weight of the machinery was twenty-five tons, and it was so arranged that the motion was communicated direct from the piston cross-head by two side rods to the crank on the paddle shaft, placed immediately behind the lower end of the steam cylinder, which was horizontal. The wheels were fourteen feet diameter, projecting five feet, and were so constructed that the float boards could be raised to suit the draught of water of the ship; or they could be taken entirely away, if necessary, leaving the shafts projecting only eighteen inches beyond the sides. Under ordinary circumstances they were disconnected from the engine by a simple contrivance, consisting of a moveable head, attached to the crank on the paddle shaft, by turning which, one quarter of a circle, the crank pin was liberated, and the wheels turned freely round. The "Vernon," thus equipped, having on board nine hundred tons of cargo, and sixty tons of coal, drew seventeen feet of water. In the first trial the speed of the vessel, under steam alone, was five and three-quarters nautical miles per hour, demonstrating how small a power is necessary for a moderate speed. She then started for Calcutta, and though the piston rod broke three times during the voyage, owing to a defect in one of the paddle shaft bearings, the passage was satisfactory. The details are given minutely, as are also those of the homeward voyage, which was performed from Calcutta to London in eighty-eight days, to which must be added seven days for necessary delay at the Cape, making a total of ninety-five days, which is the shortest passage on record. Great credit is given to Captain Denny for the judgment with which he used the auxiliary steam power, and the course taken by him, by which he was enabled to overcome the difficulties incidental to a first trial of so important a system. The success of the "Vernon," induced the immediate application of engine power to the "Earl Hardwicke" Indiaman, and both these vessels are now on their voyage out to Calcutta.

This communication was accompanied by drawings of the "Vernon" and the "Earl Hardwicke," and by a chart, on which was laid down the proposed daily course of a steam ship, on a voyage to and from Calcutta, showing where sails only were necessary, then where steam alone, and also when the joint agency of steam and wind would be required. Also, the daily progress of the "Marquis of Huntly" Indiaman, of fourteen hundred tons burthen, on a voyage to India and China, and home, from the author's own observation, in the year 1816.

For the purpose of demonstrating the ratio of power to velocity, a Table was also given showing the velocities of ships of different tonnage, having steam power of various ratios, deduced from upwards of one hundred experiments on large steam vessels. The mode of disengaging the cranks was illustrated by models showing the gradation, from the complication of the first idea, to the beautiful simplicity of the present plan, which is now employed on board of the Government war steamers.

Mr. S. Seaward.

Mr. S. Seaward explained the Table of Velocities of steam ships, which accompanied his paper.

Table of velocities.

The top line of figures represents the number of horses power, ranging from thirty to three hundred. The side line gives the tonnage of the steam ships, rising progressively from one hundred to twelve hundred tons. The intermediate spaces show the number of knots or nautical miles, which a ship of given tonnage, with a certain power, will travel through still water per hour.

The tonnage is calculated by the old rule (13 George III. cap. 74): "From the length subtract $\frac{3}{5}$ths of the breadth, multiply that sum by the extreme breadth in the widest part, and again by $\frac{1}{2}$ the breadth, divide the product by 94, and the quotient will be the true tonnage."

The Table is constructed upon the principle, that each vessel of a good modern form will carry, at a proper draught, a weight equal to her measurement tonnage, and is presumed to be loaded equal to her tonnage, either by the weight of her engines, fuel, or cargo, and it terminates at thirteen knots, at which speed the engines alone become the full load of the ship. The mode of constructing and of using the table was fully described, and examples were given.

It was shown, that an engine of thirty horses power would propel a ship of twelve hundred tons burthen, at the rate of 4 knots per hour, while three hundred horses power would only propel the same ship at the rate of $10\frac{5}{9}$ knots per hour. Hence, ten times the power would only produce about two and a half times the speed.

The principal points in the paper were more fully dwelt upon, and in answer to questions from some of the members, Mr. Seaward remarked, that no steamer in England had ever been propelled at more than fifteen geographical miles per hour, through still water.

Government Mail Packets.

In some of the Government mail packets, the engines and coals were the full cargo of the vessel. The table did not apply to vessels overladen with power, for as the weight increased in the ratio of the power, so the immersed sectional area was augmented, and the lines of the vessel which might be well calculated for speed when at a proper draught, became lines of retardation, and the engines did not work up to their proper speed, owing to the depth to which the paddle floats were immersed. For instance:—The wheels of the "British Queen" have been plunged between six and seven feet, instead of four feet, which was the calculated dip; the engines at the same time diminishing their speed so much as to reduce the effective power from five hundred horses to nearly three hundred horses.

The 'British Queen.'

The only advantageous way in which great power could be applied, would be by contriving to prevent the increase in the weight of the machinery and fuel, and those engineers would be most successful who could so apply the materials of construction, as to ensure strength without the usual corresponding increase of weight.

Mr. Mills.

Clyde Steamers.

Power to Tonnage.

Speed.

Mr. George Mills, from his experience as a ship-builder, at Glasgow, was enabled to confirm all that Mr. Seaward had advanced. On the Clyde, the employment of an excess of power in steam vessels had been carried to the greatest extent, without producing corresponding advantages, either for speed, or in a commercial point of view. It would appear that the same error had to a certain degree been committed on the Thames, but less than on the Clyde; for on the latter river there were vessels with nearly double the power, in proportion to size, as compared with any vessel on the former river. He believed that on the Thames no vessels had so much as one horse power for each register ton, whereas on the Clyde, there were steamers of seventy to eighty tons register, having single engines, with cylinders of fifty-four inches diameter, which was more than one hundred horses power. It would appear that this application of extra power had only obtained a very moderate speed, while the great first outlay, with the commensurate current expenses, had reduced the commercial profit to the lowest point,—of this the proprietors alone could give any account; but as to the speed attained, he had seen three steamers of identical tonnage leave the Broomielaw at the same time, their engines being respectively of one hundred and ten, eighty, and sixty horses power; yet their speed was in the inverse ratio of their power: the vessel with the smallest engine arrived at Greenock first, the greater power second, and the greatest last. These remarks were only applicable to river boats. With regard to sea-going vessels, the system had not been carried to so serious an extent, yet with them the average proportion was about one horse power to two register tons, and some few reached as high as one horse to one and one-eighth of a ton.

The 'Tartar' and the 'Rover.'

The 'Achilles.'

As an example of an augmentation of power producing an opposite result from that which was intended, Mr. Mills mentioned two vessels called the "Tartar" and the "Rover," built by him and his (then) partner, Mr. Charles Wood. They were each of about two hundred and twenty tons register, built from the same draught, and in every respect as similar as possible—except that the engines, which were by the same maker, were respectively of one hundred and seventy, and one hundred and thirty horses power; yet whenever they worked together, the one with the smaller power proved herself the faster vessel, either in a calm, with the wind, or even against it. The "Achilles," Liverpool steamer, which lately had an addition of thirty feet to her length, and eighteen inches to her breadth, augmenting the tonnage about one-fifth, had improved her speed upwards of one mile per hour, although she carried a much heavier cargo than before.

He had built a vessel of five hundred and sixty tons register, with engines of one hundred and thirty horses power on board—a proportion of power to tonnage of one to four; the stowage for cargo was ample; the accommodations for passengers excellent. She drew little water, and her speed was much greater than vessels of double her power. Yet in spite of all this, the vessel could not find a purchaser, because the power was not nominally large.

It would be asked—why, with these and so many similar instances, such a system was continued? It was not likely that the engineers would complain of having orders for large engines; and there were certain dimensions prescribed for the vessel, to which the ship-builder was under the necessity of conforming.

The chief cause of mischief, however, was the fiat of the public. It was believed that a great power would remedy want of speed and all other evils, and it was found indispensable for ensuring the confidence of travellers. Hence, the shipowners, who depend upon the public for support, were obliged, against the conviction of their experience, to keep up the errors occasioned by ignorance.

The President.

The Halifax Packets.

The President observed, that the condemnation of large power should not be carried too far, as experience alone had produced the increase of weight, strength, and power, of the present engines, compared with those of the early steamers which were built, instancing the Halifax Packets (Cunard's), which, with their great power in proportion to tonnage, had performed their duties satisfactorily.

Mr. Mills.

Mr. Mills explained that the Halifax Packets were built for the especial purpose of carrying the mails only, to perform the voyage in a given time,—about twelve days. The engines were built by Mr. Robert Napier, after the model of those of the "Great Western," which used their steam expansively; similar provisions had been made in the Halifax Packets, but the expansion valves were seldom used.

Mr. Field.

Mr. Field agreed with the principal part of Mr. Seaward's paper, but he would prevent an erroneous conception of the term *overpowering* a steamer. A vessel could not have too much power, provided that power could be advantageously applied, without causing too deep an immersion. A good result could be produced only by keeping a proper proportion between the machinery, the vessel, and the paddle wheels, and immersing the hull of the steamer only as deep as the true lines of draught.

Mr. Vignoles.

Mr. Vignoles observed, that in this country the reputation of engineers depended upon the commercial success of the works they engaged in. An erroneous public opinion might have influence at present; but if the engineer and ship-builder would determine to break these trammels, and produce such vessels as should force conviction upon the public mind by the speed attained, and show the proprietors the consequent commercial advantage, the present system would soon be abandoned.

Mr.Parkes

The 'Great Western.'

Uniform nomenclature.

Mr. Parkes eulogized Mr. Seaward's candour in describing the errors in the first construction of the engine on board the Vernon; more was frequently to be learned from failures than from successful efforts, and no communications to the Institution would be so useful as those which gave accounts of defective design or construction, with the details of the methods adopted for remedying the defects. He directed attention to the performances of the "Great Western" steam ship, which at least equalled those of the Halifax Packets, without the disadvantages of being unable to carry cargo, or of shipping so much sea, when the weather was foul. The important feature of economy of fuel on board the "Great Western" might be in part attributed to the use of steam expansively. It was very desirable that the Institution should possess very full drawings and a description of the "Great Western," so as to be enabled to compare them with those of the Halifax Packets, which had been promised by Mr. George Mills. He would impress upon manufacturers of marine engines the necessity of adopting a correct and uniform nomenclature of the power placed on board steam vessels. The nominal selling power did not accord with any calculation.

Mr. Field.

Mr. Field believed the Table of Velocities calculated by Mr. Seaward to be very nearly accurate. The speed of the "Great Western," when loaded to her proper draught, had been as high as $13\frac{8}{10}$th miles through still water. There was an error in the alleged speed of Cunard's vessels; they reached Halifax in ten days, Boston in three days more, and then had still one day's voyage to New York. The average duration of the voyages of the "Great Western," was about fourteen days and a half. If two hundred tons were deducted from the tonnage of the "Great Western" for cargo and the accommodation for the passengers, she would then be similar to the Halifax Packets. The engines of the "Great Western" were nominally estimated at four hundred horses power, and the average consumption of fuel was twenty-six tons every twenty-four hours.

Mr.Cubitt.

During the discussion, Mr. Cubitt had calculated the following Table, showing the rates of velocity which would be attained by substituting engine power, with its consequent weight of one ton per horse power, for cargo, so as to preserve the draught of water the same in all cases.

TABLE showing the power required to obtain various rates of speed in a steam vessel, where the total weight of cargo and engines remains in all cases the same, and in which, with a power of 30 horses, a speed of 5 miles per hour is obtained; the total weight carried being in all cases 1000 tons, and the engines weighing 1 ton per horse power.

Weight of Cargo.	Weight and Power in Tons and Horse Power.	Relative speed.	Speed in Miles per hour.
970	30	$5\sqrt[3]{1}$	5·
940	60	$5\sqrt[3]{2}$	6·299
910	90	$5\sqrt[3]{3}$	7·211
880	120	$5\sqrt[3]{4}$	7·937
850	150	$5\sqrt[3]{5}$	8·549
820	180	$5\sqrt[3]{6}$	9·085
790	210	$5\sqrt[3]{7}$	9·564
760	240	$5\sqrt[3]{8}$	10·
730	270	$5\sqrt[3]{9}$	10·4
700	300	$5\sqrt[3]{10}$	10·772
670	330	$5\sqrt[3]{11}$	11·119
640	360	$5\sqrt[3]{12}$	11·487
610	390	$5\sqrt[3]{13}$	11·756
580	420	$5\sqrt[3]{14}$	12·050
550	450	$5\sqrt[3]{15}$	12·331
520	480	$5\sqrt[3]{16}$	12·599
490	510	$5\sqrt[3]{17}$	12·856
460	540	$5\sqrt[3]{18}$	13·103
430	570	$5\sqrt[3]{19}$	13·34
400	600	$5\sqrt[3]{20}$	13·572
370	630	$5\sqrt[3]{21}$	13·794
340	660	$5\sqrt[3]{22}$	14·01
310	690	$5\sqrt[3]{23}$	14·219
280	720	$5\sqrt[3]{24}$	14·422
250	750	$5\sqrt[3]{25}$	14·62
220	780	$5\sqrt[3]{26}$	14·812
190	810	$5\sqrt[3]{27}$	15·
160	840	$5\sqrt[3]{28}$	15·182
130	870	$5\sqrt[3]{29}$	15·3615
100	900	$5\sqrt[3]{30}$	15·535
70	930	$5\sqrt[3]{31}$	15·706
40	960	$5\sqrt[3]{32}$	15·854
10	990	$5\sqrt[3]{33}$	16·037

Mr. S. Seaward.

Mr. Seaward remarked, that his Table of power and velocities was corroborated by Mr. Cubitt's—the practical results verified both. The great difference between the "Great Western" and the Halifax Packets consisted in the better adaptation of weight and power to tonnage, and the more economical consumption of fuel of the former over the latter—the one carrying cargo and passengers, the other only the engines and fuel, yet the "Great Western" travelled farther with the same quantity of fuel.

American Steam Boats.

In answer to a question relative to American steam boats, he believed that the build of the river steamers was very peculiar: some of them had engines of six hundred horses power on board, yet they drew only four feet of water, whereas a sea-going steamer with that power would draw at least sixteen feet. As far as he could ascertain, the actual well-authenticated speed did not exceed fourteen and a half geographical miles per hour through still water. The fuel consumed could not be ascertained, as it was chiefly wood, taken on board at the places of stoppage; there was a great consumption of steam at a very high pressure. Their machinery was not heavy, and was specially adapted to the vessels. Daily improvements were making in the form of vessels in England, and when high pressure steam and light engines were applied to vessels of a different form from those at present constructed, the speed must be increased. Some vessels were now building on the Thames of an extremely light construction, with tubular boilers, and the weight of the machinery would be only eleven cwt. per horse power.

February 16, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: William Radford, Henry Alexander, John Gandell, William Bagnall, Thomas Bagnall, and James Bagnall, as Associates.

"Practical Observations on the management of a Locomotive Engine." By Charles Hutton Gregory, Grad. Inst. C. E.

Management of Locomotive Engines.

The working of a railway involves a number of practical details with which it is of great importance that the young engineer should make himself thoroughly acquainted. Of these, one of the most important is the management of a locomotive engine.

The communication consists of practical remarks on this subject from the author's individual experience; it is divided into three sections:—1st. The management of an engine in the Station. 2d. On the Road. 3d. In cases of accident.

Section 1st—contains instructions as to the state in which an engine should be kept in the station, and a detailed account of the examination to which it should be subjected previously to its starting with a train. The principal working parts are mentioned, with the particular attention due to each; and the proper supplies of oil, coke, and water, enumerated. The section concludes witha list of the articles necessary to be carried on the tender.

Section 2d—enters fully into the leading points of engine-driving. After attending to the precautions to be taken in starting, the author points out the proper position of the engineman, and the attention which he should give to the state of the rails, the safety of the train, and the working of the engine. Instructions are then given for the production and maintenance of a sufficiency of steam, by the judicious management of *water* and *fuel.* The proper height of the water in the boiler is described both under general and particular circumstances, and the times at which it should be supplied: with observations on priming, on the action of the pumps, and their irregularities.

This is followed by remarks on the proper manner of supplying coke, the extent and periods of that supply, the proper height of the coke in the fire box, &c.

Instructions are given for economizing and rendering the steam most efficient; the mode of treatment to be adopted in case of extraordinary deficiency or excess; rules for stopping and starting at the stations; general hints in case of the wheels slipping, and of the heating of the axles; precautionary measures to be adopted on curves, steep inclines, dangerous parts of the road, &c.; the care necessary for an engine at the end of each journey, and when finishing its work for the day.

Section 3d—describes those accidents to which engines are most liable when running, and the steps to be taken under the circumstances: viz.—The bursting of a tube, the lagging of the boiler catching fire, the failing of the feed pumps, the breaking of an axle, of a spring, or of the connecting rod, the disconnexion of the piston, of the excentrics, or any of the slide valve gear, the fracture of the strap of the slide valve, and the engine running off the rails.

"Observations on the effect of wind on the suspension bridge over the Menai Strait, more especially with reference to the injuries which its roadways sustained during the storm of January 1839." By W. A. Provis, M. Inst. C. E.

The Menai Bridge.

In the month of December 1825, when the original construction of the bridge was nearly completed, several severe gales occurred, and considerable motion was observed, both in the main chains and in the platform of the carriage ways. It appeared that the chains were not acted upon simultaneously, nor with equal intensity; it was believed, therefore, that if they were attached to each other, and retained in parallel plains, the total amount of movement would be diminished.

Fracture of rods and bearers.

On the 30th of January, and on the 6th of February, 1826, some heavy gales again caused considerable motion of the chains and roadway, breaking several of the vertical suspending rods, and of the iron bearers of the platform.

These bearers were constructed of wrought-iron bars, overlapping each other, and bolted together, with the ends of the suspending rods between them, for the purpose of giving stiffness to the structure. The flooring planks were bolted to the bearers, and notched to fit closely round the suspending rods, which were thereby held almost immoveably in the platform.

Nature of undulation.

It was observed, that the character of the motion of the platform was not that of simple undulation, as had been anticipated, but the movement of the undulatory wave was oblique, both with respect to the lines of the bearers, and to the general direction of the bridge. It appeared, that when the summit of the wave was at a given point on the windward side, it was not collateral with it on the leeward side, but, in relation to the flow of the wave, considerably behind it, and forming a diagonal line of wave across the platform.

The tendency of this undulation was, therefore, to bend the bearers into a form produced by the oblique intersection of a vertical plane with the surface of the moving wave. The bearers were not calculated to resist a strain of this nature: they therefore were fractured generally through the eyes on each side of the centre foot-path, at the point of junction with the suspending rods, which being bent backwards and forwards where they were held fast at the surface of the roadway, were in many instances wrenched asunder also.

Repairs.

The means adopted for repairing these injuries, and for preventing the recurrence of them, were, placing a stirrup, with a broad sole, beneath each of the fractured bearers, attaching it by an eye to the suspending rod, cutting away the planking for an inch around the rods, and at the same time bolting, transversely, to the underside of the roadway, an oak plank, fifteen feet long, between each two bearers, for the purpose of giving to the platform a greater degree of stiffness, combined with elasticity, than it previously possessed. The four lines of main chains were also connected by wrought-iron bolts passing through the joint plates, and traversing hollow cast-iron distance pieces, placed horizontally between the chains.

The effects of these alterations were so beneficial, that little or no injury occurred for nearly ten years. On the 23d of January, 1836, a more than usually severe gale caused violent undulation of the platform, and broke several rods. There can be little doubt that ten years' constant friction, combined with the shrinking of the timber, had relaxed the stiffness of the platform, and permitted an increased degree of undulation. The gate-keeper described the extreme amount of rise and fall of the roadway in a heavy gale to be not less than sixteen feet; the greatest amount of motion being about half way between the pyramids and the centre of the bridge.

In consequence of the injuries sustained during this gale, the author and Mr. Rhodes were instructed to give in a report upon the state of the bridge, and on any repairs or additions which might appear desirable.

The result of the examination was satisfactory; the whole of the masonry, the main chains, their attachments to the rock, the rollers and iron-work upon the pyramids, and all the principal parts of the bridge, were as perfect as when first constructed; it was, however, recommended, that "a greater degree of rigidity should be given to the roadways, so that they should not bend so easily under vertical pressure."

Partial destruction in 1839.

The bridge remained in the same state until the hurricane of the 6th and 7th of January, 1839; during the night of the 6th, all approach to the bridge was impracticable; the bridge-keeper, however, ascertained that the roadways were partially destroyed; and he in consequence traversed the strait in a boat in time to prevent the down mail from London driving on to the bridge.

When the day broke, it was found that the centre footpath alone remained entire, while both the carriage ways were fractured in several places. The suspending rods appeared to have suffered the greatest amount of injury; out of the total number of 444, rather more than one-third were torn asunder; one piece, 175 feet long, of the N.E. carriage way, was hanging down and flapping in the wind; much of the parapet railing was broken away; the ties and distance pieces between the main chains were destroyed; the chains had resisted well in spite of the violent oscillation they had been subjected to, to such an extent, as to beat them together and strike the heads off bolts of three inches diameter.

Means were immediately adopted for restoring the roadways; and so rapidly was this effected, that in five days carriages and horses passed over, while foot passengers were not at any time prevented from crossing.

The account of the restoration of the bridge, communicated by Mr. Maude to the Institution, is then alluded to.*

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* See page 58.

The substance of the report of the author to the Commissioners of Her Majesty's Woods is then given, and a review of the proposals made by Mr. Comms, Colonel Pasley, and others, relative to the restoration.

The opinion of Colonel Pasley, " that all the injuries which have occurred to the roadways of Suspension Bridges must have been caused by the violent action of the wind from below," is then examined, and reasons given for the author's dissent from that opinion.

The action of wind.

The action of the wind upon the Conway and Hammersmith Bridges, is next examined; and from the amount of oscillation observed in all suspension bridges, the conclusion is arrived at, that winds act strongly and prejudicially on the fronts as well as on the horizontal surfaces of the platforms of suspension bridges, and that the effect of winds is modified and varied by the nature of the country, and the local circumstances connected with each individual bridge. Although differing in opinion with Colonel Pasley as to the general cause of injury to suspension bridges, the author agrees with him in the propriety of giving increased longitudinal rigidity to their platforms, to prevent or to restrict undulation. He advised its adoption in 1836, and applied his plan of stiffening by beams, in 1839. He preferred beams to trussed framing, on account of the facility with which the former could be increased in number, to obtain any requisite degree of stiffness, and because he feared that trussed frames could not always be kept firmly in their true vertical positions.

A drawing showing the injuries sustained by the platform during the hurricane of 1839, accompanied the communication.

Mr. Cowper.

Mr. Cowper was of opinion, that the real cause of injury to suspension bridges was the vibration of the chains and roadway. The whole suspended part, when acted upon by the wind, became in some measure a pendulum, and if the gusts of wind were to recur at measured intervals, according either with the vibration of the pendulum, or with any multiples of it, such an amount of oscillation would ensue as must destroy the structure. He illustrated this proposition by a model with chains of different curves, and at the same time pointed out the efficiency of slight brace chains in checking the vibration.

Mr. I. K. Brunel.

Mr. Brunel agreed with Mr. Cowper in his opinion of the cause of injury to bridges, and with the propriety of applying brace chains, for preventing the vibration. He then alluded to the introduction of lateral braces in the bridge designed by Mr. Brunel, Sen. for the Isle of Bourbon. He had been at the Menai Bridge during a severe storm, and had particularly noticed the vibration of the chains, with the accompanying undulation of the platform. The force of the wind was not apparently from beneath; it appeared to act altogether laterally. The chains were too high above the roadway; their vibration commenced before the platform moved: the unequal lengths of the suspension rods then caused the undulating motion. His attention had latterly been much given to the subject on account of the Clifton Suspension Bridge, now erecting under his direction. The span would be seven hundred feet, and the height above the water about two hundred feet. He intended to apply the system of brace chains at a small angle to check vibration. To two fixed points in the face of one pyramid would be attached two chains, each describing a curve horizontally beneath the platform, touching respectively the opposite sides of the centre of the bridge, and thence extending to similar points on the other pyramid: there they were attached to two levers, the ends of which were connected with a counter balance of about four tons weight appended to each; these weights would hold the chains sufficiently extended to enable them to resist the lateral action of the strongest winds without their being so rigid as to endanger any part of the structure. By this contrivance the platform would be kept firm, which was the chief point to be attained.

In all suspension bridges the roadways had been made too flexible, and the slightest force was sufficient to cause vibration and undulation. The platform of the Clifton Bridge would have beneath it a complete system of trough-shaped triangular bracing, which would render it quite stiff. He was an advocate for bringing the main chains down to the platform, as at the Hammersmith Bridge, and for attaching the bearers to the chains at two points only; when they were suspended by four rods, it not unfrequently happened that the whole weight of a passing load was thrown upon the centre suspension rods, and the extremities of the bearers were lifted up and relieved from all pressure. The extent of the expansion and contraction of the chains was a point of importance. In the Menai Bridge the main chains on a summer day would be as much as sixteen inches longer than in a winter's night. At the Clifton Bridge the difference under similar circumstances would be about twenty inches. The whole expansion of the back chain beyond the pyramids must be thrown into the suspended part. He would prefer having only one chain on each side of the bridge, and that chain much stronger than is usually adopted, but in deference to public opinion he had put two; he believed that they rarely expanded equally, and hence an unequal distribution of the weight of the roadways upon the suspension rods occurred. A rigid platform would in some degree prevent this, but he had endeavoured to lessen the effects of unequal expansion by arranging a stirrup at the top of each suspending rod, so as to hold equally at all times upon both the chains, and thus cause each to sustain its proportion of the load.

Mr. S. Seaward.

Mr. Seaward had never seen the force of wind exerted at regular intervals, as Mr. Cowper had supposed; if the gusts were repeated at such intervals, no suspension bridge, nor any elevated shaft or chimney in masonry, could resist them.

Mr. Rendel.

Mr. Rendel believed that the errors committed in the construction of suspension bridges had principally arisen from engineers theorizing too much on the properties of the catenary curve, without attending sufficiently to the practical effects of wind in the peculiar localities in which the bridges were placed. He could not agree with Mr. Cowper in his view of the intermittent action of the wind, or the vibrating of the chains. Observation had led him to conclude that, in the positions in which suspension bridges were usually placed, the action of the wind was not uniform; for instance, it would act at the same moment on the upper side of one end of the roadway, and on the lower side at the other end. In this case, unless the platform possessed a certain degree of rigidity, undulation was induced and oscillation ensued. Braces and stays would not counteract this—nothing but a construction of platform, which made it in itself rigid by some mode of trussing, could withstand this kind of action. He agreed with Mr. Brunel in his idea of reducing the number of the suspending chains. At the Montrose Bridge, which was 432 feet span, he had endeavoured to avoid all complexity of contrivances by adopting a complete system of vertical diagonal trussing, which was ten feet deep—five feet above, and five feet below the platform—so as to insure rigidity, and to produce that solidity which was essential for preventing undulation and oscillation.

Mr. Cowper.

Mr. Cowper reverted to the motion which he had found to be so easily produced by repeatedly exerting a small force at measured intervals against the main chains of the Hammersmith Bridge. He conceived that if the chain oscillated, the roadway must oscillate also.

Mr. Rendel.

Mr. Rendel contended that the motion produced by the impulses communicated by Mr. Cowper to the chain resolved itself into undulation, and not oscillation. He could not understand the advantages of the trussing adopted at the Hammersmith Bridge: it appeared to him that its tendency was, on the passage of a heavy weight, to relieve four out of five of the suspending rods from their due proportion of the load, and to throw it upon the fifth rod. His object in the construction of the framing of such platforms had always been to spread the load quite equally, and rendering it rigid by means of vertical trussed framing, to prevent the undulation which was the primary cause of oscillation. He would distinguish clearly between the two motions, and say, that undulation was motion in the direct line of the platform, and that oscillation was a motion at right angles with it. Vibration was identical with undulatory action.

Mr. Donkin. Mr. Donkin conceived that a good system of trussed framing could alone prevent undulation or oscillation; if the framing were placed vertically, its tendency would be to prevent undulation; if placed horizontally, to prevent oscillation: now, as Mr. Rendel had given it as his opinion, that the latter action resulted from the former, the system of trussing adopted by him at the Montrose Bridge would appear calculated to obtain the desired end. A slight exertion of force would produce a perceptible undulation, and a certain degree of vibration would result from the natural elasticity of the materials.

Mr. S. Seaward. Mr. Seaward remarked, that the degree of oscillation would appear to depend in some measure upon the distance at which the platform was suspended beneath the chains, and upon the distance between the points of suspension of the main chains; if the platform was rigidly held at the extremities, the motion would be vibratory, and not amounting to undulation.

February 23, 1841.

WILLIAM CUBITT, V.P. in the Chair.

The following were balloted for and elected: Colonel Sir Frederick Smith, R. E., William Chadwick, John Bazley White, Jun , Charles Lorimer Hensman, Joseph Whitworth, and Evan Hopkins, as Associates.

"Description of a new mode of Steering, as applied to boats of light draught of water, navigating shallow and rapid rivers." By Captain Henderson, Assoc. Inst. C. E.

The ordinary method of steering with a single rudder, fixed in the usual manner, will bring a vessel round in about four times its length, upon an axis at the point of union between the dead wood of the vessel and the rudder. It was found desirable for the particular service on the Ganges and Burhampooter, for which the vessel in question was designed by the Assam Company, that great facility should be given for coming round rapidly; to accomplish this, the stem and stern of the vessel are alike provided with rudders, of a form adapted to the curvature of the craft. The stern rudder is considerably larger than the other, and occupies the space usually allotted to the dead wood, which is cut away; a more immediate influence is thus exerted upon the boat. The rudders are raised or lowered according to the draught of water, by means of capstans fixed upon the projecting ends of the shaft of a pinion, which is geared into a toothed rack of peculiar construction, on the back of each rudder post. The effect of this arrangement is, that the centre of revolution is transferred to a point nearer the centre of the vessel, and deviating from the true centre, in proportion to the relative dimensions, position, and figure of the two rudders, and of the lines forward and abaft the vessel, which is thus brought round in little more than its own length.

The vessel, of which a model accompanied the paper, is fitted with condensing engines working expansively, with a pressure of steam of 20 lbs. in the boiler; the cylinders are placed at an angle towards the paddle shafts, and act directly upon the cranks without the intervention of side levers.

"Description of a Coffre Dam used in excavating Rock from the navigable Channel of the river Ribble." By David Stevenson.

Coffre Dam for excavating rock.

The navigation of the river Ribble being much impeded by natural bars or weirs of sandstone rock, compact gravel, or loose sand, several ineffectual attempts were made to remove these hindrances, and eventually a joint stock company, called the Ribble Navigation Company, was formed for that purpose. Messrs. Robert Stevenson and Sons (of Edinburgh) were consulted, and under their directions the present works were commenced: their plan was to cut a channel in the rock wherever it was necessary, and to remove the gravel and sand by steam dredging, forming at the same time a low rubble wall upwards of a mile in length, for the purpose of directing the course of the river so as to obtain a permanent and straight navigable track for the shipping. The first of these operations is alone treated of in the communication.

About half a mile below Preston, a bed of sandstone rock, upwards of three hundred yards in length, stretches quite across the river; some portions are entirely free from any deposit of sand or mud, and the higher parts are frequently left dry during the summer months. This natural weir exerts such an influence upon the flow of the tides, that neap tides which at twelve miles distance rise 14 feet, are not at all perceived at the quay at Preston.

Proposed works.

It was proposed to cut a channel through this bar, 100 feet in breadth, affording an average navigable depth of 20 feet at high water of spring tides. In some places, therefore, the excavation would be 13 feet 6 inches deep. After much consideration it was determined to make use of a series of coffre dams, as the most effectual and economical mode of proceeding. Their construction may be thus briefly described:—

Construction of the dam.

A double row of wrought-iron bars, 2½ inches diameter, with *jumper* points worked upon them, were inserted vertically into the rock at regular intervals of 3 feet apart laterally, the second row being placed 3 feet behind the front row. When a sufficient number of bars were fixed, a tier of planking, 3 inches thick, with clasps to enable the planks to be fixed to the rods, was placed withinside. The lower edges of the planks were cut out roughly to the inequalities of the rock; they were then lowered, and by means of an iron rod, with a crooked end, those parts which did not touch the bottom were ascertained, and a change in the form made, until the plank rested its whole length on the rock: the lower edge was then bevelled off, and being finally lowered to its place, the plank was beaten down by the force of a heavy mallet, upon an upright piece of wood resting upon the upper edge of the planks; the lower bevelled edge yielding to the blows, sunk into the irregularities of the rock, and thus ultimately, in connexion with the puddle behind it, formed a perfectly water-tight joint. The lower planks being fixed, the upper ones were placed upon them; transverse tie bars were inserted at intervals; and the clay puddle was formed in the usual manner. In order that the navigation of the river should not be impeded, the diagonal stays were all placed inside the dams. These stays had joints at the upper ends, and being slipped over the tops of the iron rods, and kept in their places by cotters, their lower ends could be moved either horizontally or vertically, as the irregularity of the rock required:—as the excavation proceeded, longer stays were easily substituted, by merely removing the cotter, sliding up the short stay, and replacing it by another suited to the increased depth. The sides of the dam were kept together by bars of iron connected to two horizontal wale pieces, 10 inches by 6 inches, placed on the outside of the vertical iron rods. When the dam was thus constructed, the water was pumped out by a steam engine of ten-horses power, with two pumps of 12 inches diameter.

The whole of the excavation, which was 300 yards in length, and 100 feet in width, was to be completed with three lengths of coffre dams, so contrived as to include within the second stretch the lower side of the first dam, in order to excavate the rock in which that row of piles was fixed. The first and second lengths have been most successfully executed; the third is now in progress, and the excavation is proceeding very rapidly. The sandstone rock does not require gunpowder. The total quantity to be excavated is estimated at 31,000 cubic yards; all the stone which is raised is used in the construction of the wall for directing the course of the lower part of the river.

Some doubt existed in the mind of the engineer as to the security of the fastening of the iron rod piles by merely jumping them from 15 to 18 inches into the rock; they have, however, proved to be perfectly firm during heavy floods, when the whole dam has been submerged, and the velocity of the current which was rushing over it was not less than five miles per hour.

This paper was accompanied by two drawings, showing the general arrangement of the work, as well as the details of the construction of the coffre dam.

March 2, 1841.

The **PRESIDENT** in the Chair.

The following were balloted for and elected: Peter Hogg, Henry Oliver Robinson, Thomas Oldham, Edward Jones Biven, and Robert Ransome, as Associates.

"On a new form of Railway Chairs and improved Fastenings." By Charles May, Assoc. Inst. C. E.

Railway Chairs.

At the suggestion of Mr. Cubitt, V.P., a series of experiments was instituted at the works of Messrs. J. R. & A. Ransome, of Ipswich, for the purpose of determining the most advantageous form of the chairs, and most secure mode of fastening them upon the sleepers of the South Eastern Railway. The result of these experiments has been to produce the cast-iron chairs, and wooden treenails as fastenings, which were exhibited at the meeting, and described by the Author.

Fracture of Chairs.

In the event of a chair breaking, it is desirable that the fracture should occur in such a manner as to prevent any of the loose pieces being thrown into situations where they would interfere with the passing trains; to ensure this, the weakest part of these chairs is across the seat—they are, however, stronger in that part than any other chair now in use. In order to ascertain the proper relative proportion between the strength of the jaw and that of the seat, many experiments were made by varying the forms, and wedging the chairs, until they broke, sometimes in one and at other times in the other part; it was then easy to add so much strength to the jaw as would, without waste of metal, cause the fracture to take place invariably across the seat.

Accuracy of form.

For the purpose of ensuring perfect accuracy of form, with a smooth internal surface, so that wedges of a uniform shape and size might be used, the chairs are cast upon metal cores; the joint-chair has an upper piece, overlapping the wedge, to keep the rail in a perpendicular position, and to prevent the end of it from being thrown up or forced away laterally, if the wedge should accidentally be removed. This form of chair was originally planned by Mr. John Harris, the engineer of the Stockton and Darlington railway, where it has been in use above twelve months, giving perfect satisfaction. The rail is so placed in the intermediate chairs, that when it receives the pressure of the wedge, it is held firmly down on the seat, against the lower part of the jaw, and at the upper part against a slightly projecting rib, which bears against the neck of the rail.

Fastenings.

The holes for the fastenings are so arranged as not to be in the same line; a large portion of the current expense of the maintenance of way on railroads arising from replacing the sleepers which have been split by the spikes being driven in the same line in the grain of the wood.

The mode of fastening adopted in this case is, to use treenails of dry English oak, compressed into two-thirds of their original bulk, by being forced under a fly press, into metal tubes, in which they are placed in a chamber heated to about 180°, where they remain sixteen hours: the pressure upon the body of the treenail (the head not being compressed) is sufficient to materially increase the specific gravity without injuring the fibre, or diminishing the strength of the wood, and it retains the form thus given until it has been driven into a damp sleeper, when the expansion is sufficient to fix it firmly.

Disadvantages of iron spikes.

The ordinary mode of fastening chairs with iron spikes has been found disadvantageous, because one blow too many causes a reaction, and frequently loosens them, whilst treenails may be driven to any depth, and the heads subsequently split with small wedges if necessary.

Rails should be 'keyed-up' so tightly as to ensure security, still leaving a large amount of surplus strength in the chair to resist any shock to which they may be exposed:—with wedges of varying dimensions, the chairs, which are frequently of unequal quality, and carelessly cast, are liable to be brought nearly to the breaking point, and to give way as soon as they are subjected to any additional strain. This has been avoided in the chairs and wedges under consideration, by giving them exact uniformity of dimensions. 'Keying-up' the Rails.

The wedges adopted are of English oak, cut out of square timber, so formed as to drive equally well with either side to the rail, and compressed into five-sixths of their bulk, by the same process as is used for the treenails. Wedges.

Many advantages will result from this form of chair and wedge, with the treenails for fastening; the time occupied in laying the rails is diminished; the holes for the fastenings may be bored in the sleepers by machinery, at a diminished cost, and greater accuracy of gauge obtained at the same time; the required inclination of the rail being given in the chair, no cutting away of the sleeper is necessary; the sole of the chair is fixed horizontally upon the surface of the sleeper, and all of them may be placed accurately in the same plane, thus bringing to bear upon the hitherto roughly executed details of railway engineering, those mechanical contrivances by which the cost is diminished, whilst the dependance upon the skill and attention of the workmen is avoided; at the same time insuring the accuracy of the line, upon which so large a portion of the economy of working a railway depends. Advantages of the Chair and Fastening.

Specimens of the chairs, wedges, and treenails, accompanied this communication.

Mr. Cubitt observed, that two modes of preparing treenails had been hitherto adopted: one was, by forcing the wood through a steel die, in which case neither the form nor the diminished bulk was preserved, as on leaving the die it swelled nearly to its original size. The other was by passing the wood between rollers: this latter process had been found to cause permanent injury to the fibre of the wood, by crushing the capillary tubes, and consequently depriving it of much of its strength. To the mode of preparing the treenails under consideration, neither of these objections existed. He anticipated many advantages from the use of this form of chair, wedge, and fastening. They would certainly be cheaper even in the first cost than the ordinary chairs, fastened down by iron spikes. The usual calculation for a double line of rail was £880 per mile for the chairs, wedges, and spikes. The cost of these chairs, Mr. Cubitt. Compressing wood. Cost of chairs, &c.

with the compressed wedges and treenails, would be £786 per mile. The price of the compressed treenails for railway purposes would be £5. 10*s*. per thousand; that of iron spikes was £6 5s. per thousand. The wedges, $2\frac{1}{4}$ inches square, cost £2 per thousand for each inch of their length, so that those for the joint-chairs, which are 8 inches long, average £16, and those for the intermediate chairs, of 6 inches long, cost about £12 per thousand. Each joint-chair, with wedge and treenails, costs two shillings and ten-pence; and the intermediate ones, with their appendages, two shillings and one penny each.

Fracture of chairs.

One great cause of expense on railways was the fracture of the chairs during the laying. He knew an instance where in a length of twenty miles of railway 180 tons of chairs had been broken, either by wedging or in driving down the spikes. This was in the ratio of one chair in ten. In the ordinary mode the oak wedges are driven home by a 14 lb. sledge hammer, whereas with the new chair the compressed wedges and treenails are driven by a light wooden mallet.

Mr. Pim.

Mr. Pim remarked that the wood fastenings used for the chairs on the Dublin and Kingston Railway had been compressed by rolling. He considered the present plan much superior.

Mr. Vignoles.

Mr. Vignoles corroborated the statement of the cost of chairs of the ordinary construction. On the railways of the north of England oak treenails had been used as fastenings for a considerable period. The plan now proposed presented many advantages, not only in the construction of the chairs, which appeared well designed and excellently cast, but in the form and mode of preparation of both the wedges and the treenails.

In answer to a question from the President, whether the compressed treenails could be applied with advantage in ship building—

Mr. Mills.

Mr. Mills was of opinion they could be so employed, provided the fibre was not injured by the process. He believed that sound wooden treenails were better fastenings for ships than iron bolts, and quite as good as copper, whilst by their use the expense was materially reduced. Turned treenails of locust wood were at present preferred to all other kinds.

Mr. S. Seaward.

Mr. S. Seaward understood that, at the Royal Dockyards, treenails which were crooked as much as three times their own diameter were preferred to straight ones. He believed that the late Mr. H. Maudslay had constructed some machinery expressly for turning them crooked.

Mr. Hawkins.

Mr. Hawkins remarked that the treenails were frequently crooked, because the rending caused them to follow the direction of the grain of the timber. Twenty-two years since, Mr. Annesley took out a patent for building ships without ribs. He used for fastenings, treenails compressed by being forced through steel dies, just before driving them into the planks, so that their expansion fixed them firmly in the planking. He built a vessel of very light construction, the sides of which were formed of five thicknesses of $\frac{3}{4}$-inch boards, held together by compressed treenails, without any ribs. It had proved very stiff and durable.

In reply to a question from Mr. Vignoles, whether the swelling of the compressed treenails in the ribs would not have the effect of preventing the possibility of the "butt end" of a plank starting—

Mr. Mills.

Mr. Mills believed that such an event was of rare occurrence; treenails were subjected more to a lateral strain; they were frequently "backed out" after the planks had been fitted into their places; when the latter were properly bent they retained their shape, and had no tendency to spring out.

Mr. S. Seaward.

Mr. S. Seaward, in support of the opinion that leaks did occur from planks starting, instanced the "Marquis of Huntly," East Indiaman, which was injured in the Downs, by a collision with another vessel; she proceeded on her way to China, but during the whole voyage out and home forty extra men were employed at the pumps. On being taken into dock, it was found that the "butt end" of one of the bow planks had started for 8 or 9 feet in length, and nothing but constant labour and attention had kept the ship afloat, at an additional expense of £7000 to the owners.

March 9, 1841.

The PRESIDENT in the Chair.

The following were balloted for and duly elected: Joel Spiller, as a Member; John Pope, as a Graduate; Thomas Routledge and Frederick Taylor, as Associates.

"Description of a Bridge for a Railway crossing above a Turnpike Road, where the depth between the soffit of the Bridge and the surface of the Rails is limited to twenty-one inches." By John Pope, Grad. Inst. C. E.

Railway Bridge.

This bridge was designed by Mr. W. Cubitt, V.P., to meet the conditions of a clause in a Railway Bill, which required that there should be a clear width of opening for headway through the bridge in every part, 30 feet wide by 20 feet high, whilst at the same time the height of the embankment limited the space between the under side of the bridge and the surface of the rails to 21 inches.

The railway is carried on three cast-iron girders, each 3 feet deep at the centre, diminishing to 6 inches at each end, with a bearing of 2 feet on cast-iron wall-plates, supported by brickwork abutments. The flanches of the girders are 8 inches wide, and the metal every where 2 inches thick. Balks of Memel timber, 12 inches square, are laid transversely, close jointed, their ends bearing upon the flanches of the girders: on these timbers the chairs are fixed, and the rails are laid. The whole depth employed is—

The flanch of the girder	2	inches
Thickness of timber balks	12	,,
Depth of the rail and chair . . .	6½	,,
	20½	inches

One of the girders on each side supports the parapet wall in which it is completely encased, and being faced with cut stone, assumes the appearance of a flat camber arch, 3 feet in depth.

A detailed drawing, showing minutely the construction, accompanied this communication.

"Description of the Arched Timber Viaducts on the Newcastle and North Shields Railway, erected from the designs of Messrs. John and Benjamin Green; and on the application of the same system of construction to oblique and other Bridges, to the Roofs of Railway Stations, and to other large Buildings." By Benjamin Green.

Arched timber viaducts.

Materials used for bridges.

The construction of viaducts and bridges forms so important an item in the cost of a railway, that the engineer is induced to devise new methods of completing his works with due regard to stability and durability, and at the same time with the least possible expense. Stone and brick have been the materials most generally used for bridges; cast-iron has been introduced where the heights were too low for the spans, in large arches, or in trussed beams where a certain clear space beneath was required, with only a limited height to the level of the rail. Timber, from its lightness, strength, and cheapness, has been extensively used, but only in spans of limited extent, owing to the sole mode of its application being by framed trusses, upon the same principles as those usually employed for roofing.

Ouse Burn Viaduct.

These considerations induced Mr. John Green, as far back as the year 1827, to make a design and model for a bridge, with timber arches resting upon stone piers. In 1833 the plan was adopted, and in 1837 it was put into execution at the Ouse Burn Viaduct, where the construction was of great extent, and the cost was an important consideration.

Construction & dimensions.

The Viaduct is 918 feet in length, and 108 feet in height from the bed of the river. There are five arches, the versed sine 33 feet, and the radius 68 feet; three of them are 116 feet span each, and two are 114 feet each: two stone arches of 40 feet span each have been introduced at each end to give length to the abutments, and to prevent the embankments from being brought too near to the steep sides of the ravine. The piers are of stone: the springing stones for the three ribs, of which each arch is composed, are on offsets, within 40 feet of the top of the piers; cast-iron sockets are there bedded in the masonry, and secured so as to receive the feet of the ribs. Two of the piers are placed upon piles; the others are founded upon the rock: immediately beneath the centre of one of them an old coal-pit shaft was discovered, and close adjoining it the remains of the working of a coal seam: both were rendered secure by being filled up with grouted rubble masonry.

The arched ribs.

The ribs for the arches are composed of planks of Dantzic deal (Kyanized): the lengths vary from 46 feet to 20 feet, by 11 inches wide and 3 inches thick: they are so disposed, as that the first course of the rib is two whole deals in width, the next is one whole and two half deals, crossing the joints longitudinally as well as in the depth. Each rib consists of fourteen deals in thickness, bent over a centre to the required form, and secured together by oak treenails 1½ inch diameter at intervals of 4 feet apart, each treenail traversing three of the deals. A layer of strong brown paper dipped in boiling tar is placed between the joints, to bed them and exclude the wet. Trussed framings and beams are secured upon the arched ribs; the platform composed of planks, each 11 inches wide by 3 inches thick, is spiked down and covered with a composition of boiling tar and lime mixed with gravel in laying on, forming a coating impervious to the wet; upon this platform the two lines of railway are laid, leaving a foot-path between them.

The centreing.

The centreing for turning the ribs was very light and simple, and as every convenience was afforded by having a railway with travelling cranes along the sides of the piers, a whole centre could be moved by twenty men from one arch, and fixed in another in one day.

The Willington and the Dalkeith Viaducts.

The author then describes the construction of the Willington Viaduct, and that which has been erected by him at Dalkeith for the Duke of Buccleuch; giving the relative costs of the three structures which have been mentioned, and stone buildings of the same dimensions: whence it appears that in the Ouse Burn Viaduct there was an economy of £9000. resulting from the adoption of this system.

Application to oblique bridges.

He then shows the application of this system to the structure of oblique bridges, particularly where a certain clear space is required beneath, and the total height is limited: this is illustrated by a description of a bridge of 71 feet span, on the Newcastle and North Shields Railway, which crosses the turnpike road at Walker, and by one erected over the River Wear on the West Durham Railway.

Shields Railway Station.

He describes also the application of the same system to the extensive buildings and sheds of the Shields Railway Station; to churches and to private houses; in the latter the arched form is very advantageous in gaining space for the upper rooms, showing at the same time the economy resulting from the adoption.

The paper is illustrated by a series of nine elaborate detailed drawings, shewing the application to every kind of construction.

Mr. Rendel.

Mr. Rendel remarked, that on those railways where first cost was a matter of importance, the introduction of a superior kind of Timber Bridge was a great desideratum. The communication proposed the application of tarred paper between the joints: from experience he could not recommend either paper or felt in such situations. He found that both substances prevented the intimate contact of the surfaces of the timber; in all framings exposed to the action of weather the tar was absorbed by the wood; the paper and felt then became saturated with and retained the moisture, so that decay very speedily ensued. The mode he at present adopted was to have all the joints and mortices of the framings very closely fitted, leaving only sufficient space at the edges to be caulked with oakum, and the joint run with pitch, like the seams of the deck of a vessel. Wherever it was practicable, great advantage would result from covering the joints with sheet lead, to exclude the moisture and prevent the decay, which was the great bar to the more general use of timber in many engineering works.

Mr. Vignoles.

Mr. Vignoles was inclined to think the curve of the arch was too steep; he should prefer its being flatter. He would not then enter into the subject, but he would present to the Institution a large model of a Timber Bridge, and with it a communication, explaining his views on this subject, which was one to which he had paid much attention.

Mr. Macneil had found constant trouble to result from the decay of wooden bridges. The Dalmarnoch Bridge, which had been erected about thirty years, now demanded continual repairs; the struts were nearly all decayed at the points of insertion into the cast-iron sockets. The original floor had been replaced by one of teak wood. Mr. Macneil.

In answer to a question from the President as to the process of "Kyanizing" timber for the Hull and Selby Railway, Mr. Timperley described the method pursued there. In a close cylindrical wrought-iron vessel, 70 feet long and 6 feet diameter, filled with a solution of corrosive sublimate, the timber was piled, leaving a space along each piece; the air was then exhausted by air-pumps to a vacuum of about 25 inches by the mercury gauge, and by the application of a force-pump, under a pressure of 100 lbs. per square inch, the solution was driven into the pores of the timber. From experiments he had made he believed that the timber was thus thoroughly saturated, and although sufficient time had not elapsed to give any correct result as to the comparative duration of the sleepers, he thought very favourably of the process. Mr. Timperley.

The original cost of the timber, which was the best Riga Balk, squared, was £5. 10s. per load (50 cubic feet). The expense of "Kyanizing" about 400,000 cubic feet, including the interest of the first cost of the apparatus, was between fourpence and fivepence per cubic foot. The process was carried on with greater rapidity, and much more effectually, than it could have been done in open tanks.

Mr. Lowe was of opinion, that although the mechanical part of this process appeared very effective, it was not really so. There were chemical difficulties: a certain length of time was required to dilute and extract the sap and aqueous matter from the pores. The greater or less duration of the process might in some measure account for the difference of the results practically obtained. Dry planks succeeded better than wet ones; with sound dry timber any solution of the metallic salts, such as the sulphates of iron or copper, was efficacious, but with wet timber he doubted whether any preparation would be effectual. Mr. Lowe.

Mr. Cooper believed that in the process of "Kyanizing" the chlorine united with the albumen, and formed chloride of albumen; Mr. Cooper.

it was possible that in the exhausting process the air contained in the timber would expand and prevent the capillary tubes from becoming perfectly saturated with the solution of corrosive sublimate.

March 16, 1841.

The PRESIDENT in the Chair.

John Hambley Humfrey was balloted for, and duly elected an Associate.

"Description of the Methods adopted for raising and sustaining the sunken Roof of St. George's Church, Dublin." By Robert Mallet, Assoc. Inst. C. E.

Raising a sunken roof.

St. George's parish Church, one of the finest ecclesiastical edifices in the city of Dublin, was completed in the year 1802, from the designs of the late Francis Johnston, Architect to the Board of Works at that time, at a cost of about £90,000.

The church had not been built many years, before the roof, which was covered with tun slating and copper, gradually sunk in several places, by which the cornices at the flank wall were pushed several inches outwards. The subsidence slowly but continually increased. The ceiling cracked in various places, the ornamental stucco work began to drop off, and in the year 1836 the state of the roof was such, that the church was deemed unsafe for use, and was shut up.

Messrs. John and Robert Mallet were consulted as to the practicability of restoring the roof. In November, 1836, they reported that they considered the ceiling might be preserved, and described the manner in which they proposed to accomplish it.

Proposed mode.

The mode proposed consisted in interweaving with and adapting to the timber framing of the roof, a system of metallic framing, so arranged, that all strain or stress should be removed from the former, and borne by the latter, as well as removing all lateral pressure from the walls of the building.

State of the roof.

A careful survey of the roof showed that the ends of several of the principals were unsound. A small hole was then bored through the ceiling, close to each queen-post, and a deal rod, ½ an inch square, dropped through each. These rods were all of equal length, and their upper ends were secured level with the top surface of the tye-beam of each principal; then with a levelling instrument placed in the gallery, observations were taken, and the exact amount of the deflection of the framing ascertained. The variation was considerable, but the greatest amount of depression was found to be $5\frac{7}{8}$ inches. The whole roof was strained and distorted, and was so unsafe that the slightest effort caused vibration throughout.

Causes of failure.

The causes of this failure appeared to be threefold: a radical want of strength in the framing of the roof; secondly, the employment of unfit tye-beams, which having been constructed during the Continental war, when timber was scarce and dear, were formed almost wholly of short lengths, averaging not more than 20 feet, lapped and scarfed; thirdly, in the queen-posts having been badly constructed and ill placed.

Proposed remedies.

Cast-iron arches.

Suspending rods.

The stone corbels, which supported the oak cantilevers, being originally cut almost through to receive the wall-plate, were nearly all broken in the middle. It was proposed, therefore, to remove the oak cantilevers and stone corbels, and to cut away the timber wall-plate beneath each principal, to level up the wall, placing a suitable cast-iron abutment piece at each end, and to spring from side to side a cast-iron arch, in "double flitches," connected through the spaces of the timber framing by hollow distance pieces, and also by a certain number of equidistant cross-heads, from which should drop down vertical suspending rods, capable of being adjusted in length, and connected with the tye-beam of the principal, so that being drawn up straight, and the respective parts secured, the weight of the whole roof would be transferred through the framing to the tye-beams; whilst they being hung from the system of suspension rods of the cast-iron arches, which would thus sustain the whole load, and their abutments being held together by the tye-bars in the chord line, the load would bear vertically upon the walls.

Cantilever brackets.

It was then determined to raise the roof and ceiling by forces applied from below; to cut away the rotten ends of the principals and to reconnect them with the walls by a modification of the cantilever bracket, invented by Mr. Alfred Ainger, and described in the Transactions of the Society of Arts (vol. 42). The whole of the oak cantilevers and stone corbels were to be removed as useless incumbrances.

Weight of roof.

The total weight of the roof being about 133 tons, each framed principal would sustain about $16\frac{1}{2}$ tons, and each vertical suspending rod about $1\frac{1}{2}$ ton.

Although the weight of material in this roof and ceiling may be considered uniformly distributed, it was impossible to foresee what change might be effected in the framing by forcing the ceiling and roof up to a level line, or what amount of force might bear upon particular points, from the elasticity of the materials being thus forcibly constrained. It hence became a matter of prudence to provide in all parts a large surplus of strength, bearing in mind that, in any complete system, "the strength of the whole is limited by that of the weakest part, and thus that partial strength becomes total weakness." The dimensions of the scantling were accordingly so calculated that the utmost strain upon it should not exceed 4·5 tons per square inch, considering 9 tons to be the practical limit to which wrought iron might be exposed.

After giving the formulæ for calculating the strains upon the different parts of the roof, with the reasons why the theoretical dimensions were in some instances departed from, the author apologises for entering so much into detail of the construction, quoting at the same time the writings of Smeaton and Telford, as abounding in the richest details of theoretic deduction, modified by practical judgment. He then proceeds to describe the means adopted.

Mode pursued.

Immediately beneath each of the fourteen queen-posts of the roof, an aperture of 30 inches square was cut through the floor of the church, and a pier of brick and cement built up from the arches of the vaults beneath to the level of the floor; on the top of each, a plate of cast iron was bedded, and upon each plate a block of oak timber about 4 inches thick.

Fourteen straight whole balks of Memel timber, each 3 feet shorter than the height of the church between the floor and the ceiling, with their extremities cut square and smooth, were placed vertically upon the blocks; upon this level a platform was laid; across the tops of the vertical balks, pieces of oak scantling were placed; fourteen powerful screw-jacks were then fixed, one beneath each queen-post, and the ceiling cut away for the points to bear directly upon the beams.

During the progress of these operations, the whole of the ceiling and roof framing had been carefully examined. The dust was removed from the joints and open mortices, &c., of the framing, and the cracks in the ceiling were cleared out by passing a fine whip saw through them, so as to permit their closing when the ceiling was raised to a plane surface.

The preparations being completed, the word was given to heave simultaneously upon the screw-jacks; the roof rose slowly and steadily, and as soon as any one of the small deal standard rods had reached the level plane, the motion of the screw-jack at that spot was stopped. In about two hours, the whole roof, together with the ceiling, was brought up level, without any accident or injury to any portion of the ceiling. The cracks in the latter as well as the joints and mortices of the framing were found to be nearly all closed. Some slates were broken, and the copper of the platform, which before was wrinkled and loose, was now found to be drawn tight over the timber sheathing.

The roof being thus supported from beneath, the masonry was cut out round the ends of the principals; the oak cantilevers and corbels of granite, and the rotten ends of the timbers, within a few inches of the inside face of the walls, were also removed.

The cantilever and abutment castings were now applied and bedded with lead and oil putty, on blocks of stone set at the level of the under side of the tye-beams, on footings of brick and cement. The chord bars were next placed, and temporarily adjusted by means of their screw nuts. The arch segments were put up in succession, their centre or key pieces bolted in, and the segments adjusted to them by means of wedges of African oak: the suspending rods were then hung on from the top shackles, and the junction made good with the tye-beams, by means of the lower cross-heads, stirrups, and shackles.

As soon as the whole system of the seven arched frames was complete, and the cantilevers adjusted to the ends of the decayed timbers, standing lengths of pine rods were placed in right lines from centre to centre of each pair of abutment cross bolts, and all the chord bars and suspending rods were brought up by means of their adjustment screws, until the united effort of the whole system had lifted and supported the entire roof and ceiling from the screw-jacks, on which they had previously rested, so that these latter all became loose.

The whole was now left quiet for some days, in order that every part might take its bearing, and that the sufficiency of the structure should be proved before the final removal of the screw-jacks, &c., which remained within about $\frac{1}{8}^{\text{th}}$ of an inch of the blocks beneath the tye-beams, by which means, in case of accident, the amount of fall would have been limited to that small distance. The entire work, including the repairing the cracks in the ceiling, occupied little more than four months, and has never since required either alteration or repair.

Cost. The total amount of the contract for this work was £1362. 6s. The repair of the injury done to the ceiling only amounted to £33. 0s. 8d., and the damage done to the slating, platform, flooring, &c., did not amount to more than an equal sum.

Weight of iron-work.

The total amount of cast and wrought iron in the structure was 21 tons 10 cwt. 2 qrs. 19 lb.

The communication is illustrated by five elaborate drawings on a large scale, showing the general arrangement and modes of proceeding, and also the details of the construction of the roof and of the cast and wrought-iron works used in the repairs.

"Description of two Wrought-Iron Roofs over the buildings at Mr. Thomas Cubitt's Works, Thames Bank." By Mr. Adams.

Wrought-iron roofs.

This communication describes in detail the construction, and gives the dimensions of the several parts of two fire-proof roofs of 29 feet span, one of which bears, in addition to the covering, a ceiling of tile arches upon iron girders, the weight of which is equal to 5 tons 4 cwt. upon each truss.

The paper is accompanied by two drawings of the roofs.

"Description of a Double Telescope Theodolite." Arranged by Nathaniel Beardmore, Grad. Inst. C.E.

Double Telescope Theodolite

The improvement in this theodolite consists in its having a second telescope fixed over the ordinary one, in a reverse position, so that the line of collimation of the two telescopes when properly adjusted should be the same. The principal advantage gained is, that a straight line may be carried out with perfect accuracy, without the tedious and uncertain process of adding 180 degrees to the observed angle and reversing the instrument.

A drawing of the instrument accompanied the communication.

"On setting out Curves for Railways." By R. C. May, Assoc. Inst. C. E.

Setting out Railway Curves.

The method of setting out curves proposed in this communication is founded upon the the 32d Prop. of the 3d book of Euclid. It consists in cutting off by a chord a segment of the circle to be described, and then finding any number of points in the curve by means of a reflecting instrument, which is set so as to reflect the angle in that segment.

The instrument which has been adapted by the author for this operation, consists of two plane mirrors, the upper one being fixed vertically upon a disc of brass, and the lower one fastened to an arm which turns upon its centre, and permits the two mirrors to be set at any angle with each other: the arm can be fixed by a clamp screw. In the case surrounding the mirrors are two holes, for admitting light, and between them is the sight hole, placed so as to bisect the angle formed by the mirrors. From the underside at the centre of the instrument is suspended a slender wooden rod, with a pointed end, weighted with lead.

Angles are taken with the instrument in the same manner as with the box sextant. To determine any point in the curve, the instrument when set fast is placed in such a position that the two given objects coincide in the mirrors, and the weighted rod being released by withdrawing a bolt, falls directly beneath the centre of the instrument, marking the required point in the curve.

The author presented with this paper a Reflecting Instrument, and field tables of chords and segments to be used in setting out curves by this method.*

March 23, 1841.

The PRESIDENT in the Chair.

William Evill, Jun., was balloted for, and duly elected a Graduate.

"An improved Plank Frame, for sawing Deal Planks of various thickness into any number of boards." By Benjamin Hick, M. Inst. C. E.

Improved Saw Frame.

The principal improvement in this machine is a novel kind of gearing for producing what is usually termed the "taking-up" or "traversing motion" of the plank during the operation of sawing.

A revolving motion is given to two pair of coupled vertical fluted rollers, by means of worms and wheels, which are worked by a ratchet wheel and catch, from the crank shaft of the machine. When a plank is introduced between the moving rollers and the fixed guides in the centre of the machine, the tendency of the motion is to draw the plank forward at each stroke, with a force exactly corresponding to the degree of resistance opposed by the teeth of the saw. By this means, the necessity of any other support or side roller to the plank, during its progress through the machine, is avoided, and any number of planks of different length, depth, and thickness, can be put through the machine after each other, without any alteration or stoppage of the work.

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* This paper, with enlarged field tables, has been published by the Author, with the permission of the Council of the Institution, to accompany the instrument.

Several minor improvements are introduced in the general arrangement of the machine, particularly in the position of the crank shaft and connecting rod, which latter is placed in the centre of the moveable frame, occupying a space which has not hitherto been made use of in machines for cutting two planks simultaneously; and by carrying the crank shaft upon the framing, instead of having it fixed upon a separate foundation, the construction is simplified as well as rendered less expensive.

The communication was accompanied by a working model of the machine.

"An historical Account of Wood Sheathing for Ships." By J. J. Wilkinson.

Wood sheathing of ships.

This communication commences with the earliest history of naval architecture, the different modes of construction, and the precautions taken for the preservation of the vessels from the attacks of marine animals.

A very early instance of extraordinary attention to the preservation of the bottom of a vessel appeared in a galley supposed to have belonged to the Emperor Trajan, A.D. 98 to A.D. 117, which was found in the fifteenth century in the lake Hemorese (or Lago Riccio), in the kingdom of Naples, and was weighed after it had probably remained more than 1300 years under water; it was doubly planked with pine and cypress, coated with pitch, upon which there was a covering of linen, and, over all, a sheathing of lead fastened with nails of brass or copper; the timber was in a perfectly sound state.

In the reign of Henry VIII. large vessels had a coating of loose animal hair attached with pitch, over which a sheathing board of about an inch in thickness was fastened "to keep the hair in its place."

It is believed that the art of sheathing vessels was early practised in China: a mixture of fish oil and lime was applied; it was very adhesive, and became so hard that the worm could not penetrate it.

The opinions of Sir Richard Hawkins, of François Cauche, and of Dampier, on the practice of wood furring, are then given at length, with extracts from their journals.

The sheathing the bottoms of ships with timber, appears to have been disapproved by these early navigators. In 1668, the officers of the fleet, then preparing under Sir Thomas Allen for an expedition against the Algerines, petitioned that their vessels might not be thus encumbered, as they were in consequence always unable to overtake the light-sailing unsheathed vessels of the enemy; the petition was granted, upon the condition that precautions should be taken by cleaning the ships' bottoms very frequently.

Milled lead sheathing.

In 1670 a patent was granted to Sir Philip Howard and to Major Watson, for the use of milled lead sheathing; it was not, however, introduced without difficulty; nor until an order was issued that "no other than milled lead sheathing should be used on his Majesty's ships." About the year 1700 the lead was acknowledged to have failed, and wood sheathing was again introduced.

Numerous instances are given of the employment of wood as sheathing for ships in celebrated expeditions: the ravages of the worm, the accumulation of barnacles and weeds, are then described; the qualities of the wood employed for sheathing in different countries, both formerly and up to the present time, are examined, and the author, who undertook the investigation of this subject in consequence of finding how little good information existed in an accessible form, promises the history of metal sheathing in a future communication.

"A Machine for bending and setting the Tire of Railway Carriage Wheels." By Joseph Woods, Grad. Inst. C. E.

Tire bending machine

The usual mode of bending tire bars was by means of swages and hammers round a fixed mandril; after being welded, they were stretched on a cast-iron block formed of two semicircular pieces hinged at one point, and wedged apart at the opposite side; the hoops being heated were placed on this block, and by repeated blows driven into close contact with the mould.

Much difficulty was experienced in thus making up tires for large railway wheels, and the present machine was constructed for facilitating the process.

One end of the tire bar when heated is wedged into contact with one of four segments of a circle, of the required diameter, upon a cast-iron table, which is caused to revolve slowly; the pressure of a guide wheel at one side forces the tire bar to wrap round the segments, and to form the circular hoop required; its ends having been previously scarfed, are then welded together.

The tire is again thoroughly heated and placed around the four segments, which slide radially on the table, and are then simultaneously forced outwards by a motion of the centre shaft.

The tire being slightly chilled, and assisted by the swage and hammer, soon adapts itself to the segments, and forms a circular hoop instead of two semi-circles irregularly joined at their points of contact, as by the old system; it is then ready for being chucked on the lathe, and bored out before shrinking on the wheel.

It is apparent that a machine of this description becomes applicable to tires of any diameter, by having three or four sizes of segments adapted to the table. It is found to diminish the manual labour, and to prepare the tire more accurately than by the usual process.

A model of the machine, and a detailed drawing of the several parts, accompanied the communication.

"On the improvement of the Roads, Rivers, and Drainage, of the Counties of Great Britain." By Robert Sibley, M. Inst. C. E.

Improvement of Counties.

The author had on a former occasion drawn the attention of the Institution to the subject of a Bill before Parliament, "for the better regulation and general improvement of the Drainage of the Country;" and at the same time pointed out the course pursued by the magistrates of the County of Middlesex, in procuring with his professional assistance an accurate account of the Rivers, Bridges, &c., hoping that it might lead to similar surveys in other counties.

In the present communication he investigates the nature of the works which each county may be expected to undertake, and the means of accomplishing them economically, so that real public benefit may accrue.

The objects principally requiring the attention of the county magistrates, he considers to be, First—Facility of intercourse by the improvement of the roads, bridges, rivers, and canals. Secondly—Protection from injury by the passage of the waters from or through the county; and Thirdly—The removal of causes tending to vitiate the atmosphere, or to render unwholesome the water used for the support of human life.

All these points, which do not appear to have been fully comprehended in the Sewage Acts, are examined at length, and suggestions are offered for their regulation, with examples of the effects resulting from their neglect.

The advantage of placing the water-courses of the country generally under a well-regulated system of management, is insisted upon as the most effectual mode of guarding against the destruction of property, and not unfrequently of human life, which ensues from the effects of sudden inundations, such as have recently occurred in the county of Middlesex.

March 30, 1841.

The PRESIDENT in the Chair.

The following were ballotted for and elected:—Matthias Wolverley Attwood, M.P., Samuel Collett Homersham, and James Munday, as Associates.

"Description of a new Universal Photometer." By Dr. Charles Schafhaeutl of Munich, Assoc. Inst. C.E.

New photometer.

The inadequacy of the photometric instruments invented by Pictet, Rumford, and others, is universally acknowledged. The bromide of silver, as used by Sir John Herschell, although extremely sensitive, is only slightly affected by artificial light.

These circumstances induced the author to complete the present instrument,* which he contemplated about twelve years since.

The intensity of the undulations of gaseous fluids, as well as that of the air, is proportional to the amplitude of the oscillations, or more properly to the square of the amplitude.

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* The instrument was constructed by Mr. E. M. Clarke, 428, Strand.

A wave of light striking the retina must create a similar vibratory motion in the nerves of the retina, because the velocity of the molecular movement of the nerves depends upon the force with which they have been struck by the original wave, and if this velocity could be measured, it would show at the same time the intensity of light.

It is scarcely possible to obtain a direct accurate measurement of this velocity, but if the time during which the vibratory motion of the nerves ceases, be ascertained, the velocity of the vibrating molecules, and therefore the intensity of light, may be determined; because the duration of an impression on the retina is dependent on the resistance which the molecules of the nerves oppose to every force striking them; but as this resistance of the nerves increases as the square of the velocity, four times the momentum or intensity is necessary to double the time of duration; or, in other words, the intensity of the pencil of rays is as the square of the time of the duration of that impression made on the nerves of the retina.

Construction of the instrument.

The new photometer consists of a brass bar fixed vertically in a stand, carrying at its upper end a small tube in two parts, which may be lengthened from 5 to 10 inches if requisite. This eye tube has at each end a sliding plate pierced with holes of corresponding diameters. From the bottom of the bar a projecting arm sustains the lower end of a strip of rolled steel 18 inches long, $\frac{5}{16}$ths inch broad, and $\frac{1}{32}$nd inch thick; this has at the upper end a thin plate pierced with a small hole, corresponding with the holes in the sliders, and standing $\frac{1}{8}$th of an inch from one of them: upon the main bar is a prism with a slit in it, through which the strip of steel passes; this prism can be moved up or down by a rack and pinion, so as to lengthen or shorten the vibrations of the strip.

Method of use.

The method of using the instrument is to adjust the two holes at the opposite ends of the horizontal eye tube, so that they perfectly correspond, and do not permit any rays of light to enter, unless the plate at the extremity of the spring be pushed aside. The light to be compared is then placed at a certain given distance behind the plate, so that by bringing the axis of the hole which is pierced in it into the axis of the tube, a small pencil of light may enter the pupil of the eye. The prism is then placed at 100 of the scale on the side of the brass bar, and the steel strip caused to vibrate gently. A luminous disc immediately appears, accompanied by scintillations, which are caused by the impressions on the retina being interrupted by dark intervals: the prism is then gradually raised until the length of the vibrations of the strip being diminished, and the velocity increased, the luminous disc appears perfectly steady and clear. The length of the vibrating portion of the strip is then read off by the verniers marked on the brass rod, and compared with the whole length of the spring, measured from 100, which is considered as unity. The number of the vibrations to be computed from the found length of the spring, are inversely to the numbers of vibrations of the whole length, as the squares of their relative lengths. Hence are constructed the formulæ for calculation, which are given at length in the communication.

A fresh luminous impression is made on the retina as often as the circular aperture in the screen on the top of the spring cuts the axis of the tube. If the duration of the small vibration of the nerves of the retina is shorter than the time of a vibration of the spring, a dark interval appears between the two luminous impressions. In this case the vibration of the spring is shortened until the next impression returns just as the first ceases, and therefore the dark interval disappears; then by measuring the length of the shortened spring, the number of vibrations can be computed, and from them the intensity of the light.

This communication was illustrated by a series of experiments upon different lights, with the Photometer which was presented by the author to the Institution.

"On the circumstances under which the Explosions of Steam Boilers generally occur, and on the means of preventing them." By Dr. Schafhaeutl, of Munich, Assoc. Inst. C.E.

Explosions of Steam Boilers.

In this communication it is assumed, that perhaps not one-tenth of the recorded explosions of steam boilers can be correctly attributed to the overloading of the safety valve, or to the accumulation of too great a quantity of steam in the boiler. The author alludes to the degree of pressure which hollow vessels, even of glass, are capable of sustaining, if the pressure be applied gradually. He found, in repeating the experiments of Cagniard de la Tour, subjecting glass tubes of one or two inches in length, one-fourth part filled with water, hermetically sealed, and immersed in a bath of melted zinc, that they apparently sustained the immense pressure of four hundred atmospheres, without bursting; but if the end of an iron rod was slightly pressed against the extremity of the tube, and the rod caused to vibrate longitudinally by rubbing it with a leather glove covered with resin, the tube was invariably shattered to pieces.

Hence he concludes, that something more than the simple excess of pressure of steam in the boiler is necessary to cause an explosion, and that a slight vibratory motion alone, communicated suddenly, or at intervals, to the boiler itself, might cause an explosion. From the circumstance of safety valves having been generally found inefficient, he concludes that a force has operated at the instant it was generated in tearing the bottom or sides of the boiler, before it could act upon the safety valve.

From the sudden effect of this force, explosions have been ascribed to the presence of hydrogen, generated by the decomposition of water: but independently of the difficulty of generating a large quantity of hydrogen in such a manner, it could neither burn nor explode without the presence of a certain quantity of free oxygen, or atmospheric air; and such an explosive mixture would not take fire, even if mixed with 0·7 of its own volume of steam.*

Sudden conversion of water into steam.

The ordinary mode of converting water into steam is by successively adding small portions of caloric to a relatively large body of liquid; but if the operation was reversed, and all the heat imparted to a given quantity of water in one unit of time, an explosive force would be developed at the same moment. For example, if a bar of iron be heated until it is coated with liquid slag, and is then laid upon a globule of water on an anvil, and struck with a hammer, the liquid slag communicates its caloric instantly to the water, becoming solid at the same time that the water is converted into vapour with a loud report. A similar occurrence may take place in a steam boiler when a quantity of water is thrown into contact with an overheated plate, either by a motion of the vessel, or from a portion of the incrustation formed on the bottom or sides becoming loosened. A sudden opening of the safety valve may, under certain circumstances, prove dangerous, or even any rapid increase of heat which would cause a violent excess of ebullition in the water.

An examination is then entered into of the respective powers of water and of steam, to transmit undulatory motion, and of their compressibility. According to Laplace, the conducting power of steam at our atmosphere and 294·1° Far. is 1041·34511 feet per second, and that of water 6036·88 feet. The ratio of these different velocities is therefore as 1 : 4·5.

In cases of a sudden explosive development of steam, the principal action is directed against the bottom or the sides of the boiler, whence spreading itself through the water, it is finally transmitted through the steam to the safety valve: a wave created by an explosion, even at the surface of the water, would reach the bottom or the sides of the boiler, 4½ times sooner than it would affect the top of the steam chamber: but if it took place at the bottom, the time for the explosive wave to reach the safety valve would be the sum instead of the difference of both velocities. Although these relative periods of time may be considered as infinitely small, it is contended that there is sufficient delay (counting from the moment at which the plates begin to yield) to cause the rupture of the material which would otherwise have yielded by its own elasticity had the time been greater, as all communication of motion is dependant only on time.

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* See the author's Experiments, *Mechanics' Magazine*, vol. xxx. p. 144.

Experiments upon wires.

To illustrate the effect of the sudden development of an explosive force upon the plates of a boiler, the author gives the results of a series of experiments made by him upon iron wires, for the purpose of ascertaining the amount of elongation which took place before yielding under the sudden application of a given weight. The result was, that a wire which had resisted a tension of 22 cwt. when gradually applied, broke invariably, without any elongation, when the same force was suddenly applied by a falling body.

Upon railway bars of different qualities.

Similar experiments with railway bars showed that fibrous iron, which supported a gradual tension, broke by the sudden application of the same force; while close-grained iron, which was incapable of resisting the gradual strain, bore perfectly well that of sudden impact. These facts are worthy of consideration in the selection of iron for boiler plates, where the sudden action of the rending force is to be guarded against.

The details are then given of a series of experiments, illustrating in an ingenious model, by means of an explosive mixture of chlorate of potassa, the effects of explosions at different heights within a boiler.

Proposed safety valve.

A careful examination of the circumstances, and the results of his experiments, convinced the author that a simple mechanical arrangement, applicable to all boilers, might be introduced, so as to diminish the danger arising from the sudden development of an explosive force. He proposes to connect with the bottom of the boiler, by means of a pipe, an extra safety valve of a given area, loaded to five-sixths of the absolute cohesive force of the boiler plate. In the event of a sudden development of steam, the first shock would act upon the valve and open it, which would have the effect of depriving the wave generated of its destructive force, and at the same time diminish the violence of the second shock from the top of the boiler, having permitted the escape of a portion of the water from the boiler.

The apparatus for conducting the experiments was presented with the communication.

Mr. Parkes Steam Boiler explosions.

Mr. Parkes stated, that he had been occupied for several years in collecting facts illustrative of the phenomena of steam boiler explosions. These disasters could not all be referred to one cause. A boiler might be too weak to sustain the pressure within it, and a rupture would be the necessary consequence. But though the simple elastic force of the steam might thus occasionally account for the rending of a boiler, that cause was insufficient to explain many well-known phenomena, such as the projection of an entire boiler from its seat, the separation of a boiler into two parts, the one remaining quiescent, the other being driven to a great distance, &c. He was of opinion that a very sudden development of force could alone have produced such effects.

Dr. Schafhaeutl had ingeniously shown that an explosive force generated under water would act upon the bottom of the boiler and burst it, before the safety valve could relieve the pressure. The Doctor deduced from Mr. Parkes's theory of "the percussive action of steam," and his own experiments, that if, from any cause, such as the breaking up of a portion of crust adhering to the bottom of the boiler, a volume of steam of high elastic force was suddenly evolved, a rupture of the bottom would be the consequence, or, the boiler might be separated into two parts. Mr. Parkes coincided in this opinion, and cited several examples in support of it.

It appeared to him that a force different from, and greater than, the simple pressure of the steam, was the principal agent. The Committee of the Franklin Institute, and others, who in their experiments had endeavoured to produce explosions of boilers, had very rarely succeeded, and the effects obtained fell far short of those which continually occurred by accident. It might be safely inferred from this fact, that the experimenters had not arrived at the true cause of the ruptures and projections of boilers, otherwise the production of similar effects would not have been difficult.

Describing the sudden development of a volume of steam, from highly heated plates, which no practicable number of safety valves could discharge quickly enough to save a boiler from destruction, he instanced the effects produced by the breaking up of the scale in salt pans. Carbonate and sulphate of lime were separated from brine by evaporation, and adhered very firmly to heated surfaces. A crust of salt frequently formed upon this deposit; the cessation of ebullition (if the deposit occurred over the furnace) was the consequence, and the bottom of the pan became red hot. The manner in which the pan scale was disengaged, was to strike it with the edge of a heavy iron pricker, which allowed the brine to reach the plate; it was also frequently broken through by the expansion

Salt pans.

and bagging down of the plates, leaving the crust above like an arch. In such cases the plate was seen for an instant to be red hot, and immediately afterwards an immense column of brine was projected from the pan, the steam evidently being of high momentary elasticity. Mr. Parkes had seen a yard square of scale thus burst, the whole surface of the plate being at a glowing red heat. Had the pan been closed, like a steam boiler, he conceived that the blow of the steam on the roof, bottom, or sides, would have destroyed the vessel.

A thin copper salt pan at Mr. Parkes's Works, had a hole burst through its bottom by the sudden action of steam thus generated. The spot had no doubt been previously injured by heat. He conceived that similar phenomena might, and frequently did, occur in steam boilers.

Heated plates.

A theory had been adopted by many writers on the explosion of steam boilers, that red-hot iron plates would generate less steam than plates at a less heat. This was founded on the experiments of Leidenfrost, Klaproth, and others, on the length of time requisite to evaporate a small globule of water in a red-hot spoon. But there was no analogy between the condition of a hot spoon containing a drop of water, and that of a body of water and heated plates in boilers.

Steam of great force would instantly be produced from a thin sheet or wave of water, passing over hot plates, the molecular attraction of a drop falling a short distance upon a plate would be destroyed, and the whole be instantly converted into steam of a high momentary elasticity. The theory of the hot spoon experiment, as applied to boilers, had been demonstrated to be fallacious by Dr. Schafhaeutl in a paper published in the *Mech. Mag.* vol. xxx. No. 799.

'Union' Steamer at Hull.

The explosion of several boilers had been attributed, and Mr. Parkes thought justly, to a wave of water washing over highly heated plates. He believed that the fatal accident to the "Union" steamer at Hull was so produced. The boilers of steam vessels were not at that period so well arranged as at present, for preventing the water from flowing to one side, and leaving a portion of the top of the flues dry with the fire beneath. Under such circumstances, the disaster which occurred would be inevitable, on the vessel's coming on an even keel. Mr. Parkes was not of opinion that it required the exposure of a large area of heated metal to effect the separation of a boiler and the projection of the upper half of it; as, in this case, it was the suddenness of the action, no number of safety valves could have deprived the steam of its instantaneous force, so as to have saved the boiler. The entire circumference of large boilers had been frequently divided as clean as a pair of shears would have accomplished the work. These phenomena were evidences of a force very suddenly exerted.

Sudden actions on the surfaces of boilers arose also from other causes than the heating of plates. During the inquiry into the causes of steam vessel accidents, he ascertained that of twenty-three explosions, nineteen occurred on the instant of starting the engines, or whilst the vessels were stationary; three only whilst the engines were at work: the greatest number took place at the moment of admitting the steam upon the piston. He attributed this effect to the steam's percussive force, which would be as much felt by the boiler as by the piston; if the boiler was weak, and, distended by steam to nearly the bursting point, the shock would be sufficient to cause its rupture. Mr. Parkes then gave several instances of such occurrences.

Steam Vessel explosion at Norwich.

In 1817, the boiler of a steam vessel at Norwich burst, and killed many persons. Previous to the accident, the boiler leaked in several places; the steam issued copiously from the safety valve, which was evidently very heavily loaded. The engine had scarcely made a revolution before the explosion occurred. By applying the present state of our knowledge to these facts, he felt assured that the steam's impact on the piston had been the immediate cause of that accident.

Explosion at Passy.

In 1826 or 1827, Mr. Parkes witnessed the effects of an explosion, a few minutes after its occurrence, in the neighbourhood of his works, near Paris. The boiler was of wrought iron, 6 feet long by about 2 feet 6 inches or 3 feet diameter. By his advice the owner had previously put in a new end, formed of one piece of hammered iron, and he was strongly dissuaded from overloading his engine, or using habitually such enormous pressures. The cylinder of the engine was horizontal, and was connected with the boiler by a short pipe and cock. The proprietor informed him, that finding his machinery working too slowly, he went into the engine-house and stopped the engine. He held down the lever of the safety valve, and on turning the cock to start the engine, the explosion instantly occurred. The new end of the boiler, which was opposite to the engine, was found separated from the body, and lying in the flue. The line of rivets and a complete ring of the new end remained upon the body, apparently little forced, and the faces of the fractured ends were as sharp and clean as if cut by a chisel or shears. The boiler, engine, and masonry, were driven into the yard in the opposite direction to the escape of the water and steam; thus, though the entire end of the boiler was removed, and the whole contents evacuated, it acted too late as a safety valve.

Explosion at Camden Town.

He observed similar effects last year in an explosion at Camden Town, being fortunately on the ground to investigate it before much change had been made. Two boilers were set end to end with a chimney between them. The end of one was blown out, and was lying close to its original seat. It was forced backwards into the chimney, which it partly supported on a pipe flange, and pushed the other boiler and entire masonry in a horizontal direction fully two feet. He considered that the percussion of the steam from its re-action against the opposite ends of the boiler in the act of tearing it off (which was the effect in this case) produced the recoil. In this case there were upon the boilers (which were connected together) two safety valves in good order, and not heavily loaded. The accident occurred during the breakfast hour, whilst the engines were not at work. One of the two stays which originally held the fractured end of the boiler, was found to have been previously broken, as its separated ends were covered with old lime scale—the other had evidently been long cracked, and was only held by a fragment. The fractured end of the boiler was not exposed to the fire, nor did the shell or the flue within it exhibit any marks of injury from fire or from dislodgement of scale. The steam, in its effort to escape, acting first against one end, not only raised the boiler from its horizontal position to an angle of about 45°, but gave it a twist obliquely from the line of its bed.

High and low pressure.

Mr. Parkes could not agree in the often expressed opinion, that what are called high-pressure steam boilers were more dangerous or more liable to explode than others. Much depended on care and management. He believed that he was in possession of accounts of nearly all the explosions which had occurred in Cornwall since the expiration of Mr. Watt's patent, when higher pressures began to be used, and they amounted only to five or six instances, exclusive of some cases of collapsed flues. More explosions had occurred in a small district round Wednesbury during the present year with low-pressure boilers, than in Cornwall in forty years, where the highest pressures were employed. He believed also that the coal districts of Northumberland, Durham, and Staffordshire, would furnish more cases of these disasters from boilers both of high and low pressure, than all the rest of England put together.

Cornwall.

The coal districts.

When the practice in the coal districts was contrasted with that of Cornwall, the explanation was simple. Where coal was so cheap, the quantity used was unlimited, the negligence was great, and the allowance of boiler was small for any given sized engine, as enough steam could be raised by fires of greater intensity—the rule there being, to save in the first cost of the boiler; in Cornwall, on the contrary, the object was to insure economy in the consumption of fuel; consequently, all that class of accidents arising from injury to plates by fire and deposit, would be in about the ratio of the intensity of the combustion.

Notwithstanding the bad practice generally prevailing in the coal districts, there were some exceptions. At an iron work near Dudley, there were boilers now in good order after nearly thirty years' use, having required but trifling repairs during that period. In those boilers the plates of the bottoms which were exposed to the fire were all made of hammered, not of rolled iron—the boilers were large for their work, and were cleaned thoroughly every week.

Hammered plates.

Tilted plates were alone used for salt pans in those parts where the heat was most intense. Though continually heated to redness, and distorted by the action of the fire, the quality of the iron in plates thus formed did not appear to be deteriorated, for when taken out the smiths used them for making rivets, nails, &c. Rolled iron plates would do for making coarse salt, which required a heat below ebullition, but they were quickly injured when used for fine salt, and were useless when taken out.

Explosion at Essonne.

Mr. Parkes then adverted to several other remarkable cases of explosion. It was a well-authenticated fact, that a boiler belonging to Messrs. Ferey, at Essonne in France, exploded on the instant of opening the safety valve.

Explosion at Lyons.

Three successive reports were heard when Steele's steam boat boilers exploded at Lyons, indicating that they did not burst at the same instant. Now, though Mr. Steele had fastened down the safety valve to increase the pressure of the steam, yet the explosion of the first boiler should, according to the received opinions, have acted as a safety valve to the second and third, and have saved them—for, by the destruction of the first boiler, the pipes would be broken, and a free exit be afforded for the steam in the others; nevertheless, they all three burst in succession. Several similar instances of successive explosions had occurred in England. He would not at present enter upon an explanation of what he considered might have occasioned these phenomena, but he would express his conviction that the practice of suddenly opening and closing the safety valves was extremely dangerous. To be useful as escape valves, they should be allowed to open and to close in obedience to the steam's pressure only, not to be handled more than was absolutely necessary.

Projection of boilers from their seats.

None of the theories yet advanced appeared clearly explanatory of the cause of the projection of heavy boilers from their seats, when in many cases they contained abundance of water. He instanced a case in which a boiler exploded, and carried to some distance a boiler connected with it, and in which some men were at work. The boilers separated while in the air, and the one which exploded attained a very considerable height, although it was 28 feet long by 6 feet diameter The particulars of this explosion were furnished to him by Mr. Clarke, engineer to the Earl of Durham, but they could not be properly appreciated or explained without the drawings and description.

Explosion at Durham.

A boiler weighing about 2½ tons was projected from its seat at Messrs. Henderson's Woollen Factory at Durham, in 1835; it ascended to a considerable height, and fell 300 yards from the place where it had been seated.

Crenver Mine.

A cylindrical boiler exploded at the Crenver Mine in Cornwall in 1812. It passed through the boiler house, and opened itself in the yard outside, where it was described to have fallen "as flat as a piece of paper."

Facts of this nature were replete with interest, and should lead engineers to the consideration of causes and remedies.

Boilers red hot.

Mr. Parkes then instanced several cases of boilers which had become red hot, and had not exploded; one example was a set of three boilers, the tops as well as the bottoms of which were red hot, in consequence of the house in which they were fixed being on fire; yet they did not explode. No water had, however, been pumped into the boilers whilst so heated.

Explosions of hydrogen gas.

He was in possession also of several curious examples of ruptures and projections of vessels arising from causes very different to the foregoing. One case occurred in February 1837, at the Works of Messrs. Samuel Stocks and Son, in the Township of Heaton Norris, near Manchester. The boiler was 20 feet long, 9 feet wide, and 10 feet deep, and weighed about 8 tons. On a Saturday night the water was blown out of it through the plug-hole at the bottom, by the pressure of the steam, the man-lid not being removed. On Sunday evening the fireman proceeded to take off the man-hole cover to clean the boiler; on entering it with a candle and lanthorn, a violent explosion occurred; and the man was projected to some distance and killed. On examining the boiler it was found quite dry, no fire being alight, no traces of water near it, and it was quite cold: it had been lifted from its seat up to the roof, which it destroyed, and the walls of the building were thrown down. There was no difficulty in accounting for the presence of a combustible gas, as hydrogen might be evolved from the decomposition of the steam (which would remain in the boiler after the expulsion of the water) by the heated sides and bed of the boiler, and the atmospheric air which entered through the plug-hole or through the man-hole, when the lid was removed, was sufficient to form an explosive mixture. The projection of the man was the simple effect of firing the gas; but to account for the entire boiler being carried from its seat, was more difficult. The figure of the boiler after explosion exhibited two distinct actions; the ends and sides had evidently been bulged outwards by the force of the explosion within it, and the bottom had been crushed upwards by the force which raised it from its seat.

Mr. Parkes thought the circumstances admitted of a satisfactory explanation, but would not then enter upon it, as it involved the history and phenomena of projections of vessels from their beds with a vacuum within them, which he thought would be better understood after the reading of his paper on the "Percussive Force of Steam and other Aeriform Fluids," then in preparation for the Institution.

Boiler in London.

The foregoing case of the formation of hydrogen gas in a boiler, after all the water had been evacuated, was confirmed by one which took place in a similar manner at the Sugar-house of Messrs. Rhodes and Son, in London, of which all the particulars had been furnished to him by Mr. Henrickson, the manager. A man entering the boiler with a candle and lanthorn to clean it, was projected to a great height. No rupture of the boiler took place, as the quantity of hydrogen seemed to be comparatively small, and to be confined to the upper portion of the boiler, but a series of detonations occurred, like successive discharges of cannon.

These two remarkable instances showed the importance of attending to minute circumstances in the management of boilers. The practice of completely blowing out boilers whilst the flues were intensely heated, was evidently dangerous, nor should it be done without removing the man-hole cover.

Mr. Parkes felt that these notices of explosions were very imperfect without drawings, and reference to documentary evidence, but, as the subject had been brought before the Institution by Dr. Schafhaeutl, he hoped that they would be received as contributions to the stock of knowledge, and as illustrative of the precautions to be observed by attendants on steam engines.

Mr. Seaward was glad to find the idea of the explosions of boilers arising from the formation of hydrogen gas, so successfully combated by Dr. Schafhaeutl and Mr. Parkes. He perfectly agreed with the former in his opinion of the causes of the majority of explosions. In all that he had witnessed the effects of, the lower parts of the boiler appeared to have suffered most.

Mr. S. Seaward.

He was at the Polgooth Mine immediately after the explosion there, when seventeen persons were killed. In that case, he was told that the boilers were moved a distance of 7 or 8 feet from their seats, before any detonation was heard.

Polgooth mine.

At the Hurlam Mine (which Trevithick had undertaken to drain for a certain sum) an engine with a cylinder of 40 inches diameter was erected immediately over the shaft. Its power was not sufficient for the work required; the pressure of steam was therefore gradually increased as the depth became greater. At length the boiler, which was of an immense length, was observed to have a constant tremulous or sinuous motion at each stroke of the engine, and eventually it exploded.

Hurlam mine.

It appeared that there were fewer explosions of boilers in London, in proportion to the number employed, than in any other district. One reason for this might be, that fuel being expensive, it was used economically, by maintaining a slow rate of combustion, and a regular supply of steam, avoiding the intense action of the fire, which, in the event of the engine standing still for a time, had a tendency to produce an explosion.

Boilers in London.

Mr. Parkes attributed the small number of explosions of boilers in the vessels on the Thames to the practice of allowing the steam to act upon the safety valve, instead of the engineer lifting it when the engine was stopped, as on board vessels in the north. The sudden closing of the valve had in many cases produced an explosion. While on this subject, he felt it necessary to comment upon what he considered fallacious reasoning of Tredgold on the formation of hydrogen gas in boilers.* The passage he alluded to was couched thus:—" Hydrogen gas may be, and frequently is, formed in steam boilers through the water being in contact with a part of the boiler which is red hot; and it seems to be regularly produced during the formation of steam at very high temperatures." Dr. Schafhaeutl had shown, that the effect of water coming suddenly in contact with a part of the boiler which was red hot, was only to disengage instantaneously a large volume of steam of very high elasticity. Mr. Parkes contended, that an instance of the sudden production of

Mr. Parkes.

Formation of Hydrogen Gas in boilers.

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* Tredgold on the *Steam Engine*, vol. i. p. 251. Edition by Woolhouse.

hydrogen gas in a boiler under such circumstances was unknown, and he much doubted the possibility of such an occurrence. Again, allowing such an event to be possible, an explosive mixture of gases must be formed before the boiler could be destroyed; and this could not take place so long as a sufficiency of water was present, from which any considerable quantity of steam could be generated.

Mr. Donkin. Mr. Donkin did not entirely agree as to the non-formation of hydrogen in boilers under peculiar circumstances. He conceived the explosions which occurred in iron founderies, on the contact of the melted metal with wet sand, to be analogous. He believed, that when water was thrown suddenly upon red-hot plates, decomposition did occur.

He had once examined a waggon-shaped boiler which had exploded; the top was thrown to some distance, and the bottom was depressed throughout its entire length. He believed, that by intense firing the water had been nearly all evaporated; the bottom had then become red hot, the pressure of the steam had forced the bottom downwards when weakened by the heat; the water on each side then suddenly flowed on to the heated part, and an explosion instantly occurred.

Mr. S. Seaward. Mr. Seaward had known instances of the internal tube of a boiler being collapsed without any injury to the external part or body of the boiler. He had always ascribed such occurrences to a deficiency of water; but Dr. Schafhaeutl's explanation of the rapid transmission of force through the wave to the bottom would sufficiently account for the effects which had been observed.

Mr. Donkin. Mr. Donkin believed, that in almost every case the unequal pressure upon the exterior of the tube, arising from its not being perfectly cylindrical, was the cause of its collapsing.

Mr. Field. Mr. Field was inclined to attribute all the explosions which he had witnessed to simple pressure.

When steam, or a small quantity of water, was suddenly admitted into a dry heated vessel, hydrogen gas was readily formed. He had made several sets of apparatus for the purpose. A strong wrought-iron tube was heated, and, being filled loosely with fragments of iron-turnings, steam was introduced, and the gas was rapidly evolved.

He agreed with Mr. Parkes in condemning, generally, the fallacy of the opinion of Tredgold, previously mentioned, as to the formation of hydrogen gas. Still, in a large boiler, almost dry, and of which a portion was red hot, he conceived, that on the admission of a small quantity of water, hydrogen gas might be evolved.

The President. The President was unwilling that this conversation should terminate without endeavouring to explain the cause of the elevation of the boilers from their seats. In his opinion, this might be satisfactorily accounted for by the action of atmospheric pressure.

Elevation of boilers from their seats.

When an explosion took place in a boiler, a considerable body of highly elastic fluid was disengaged; a partial vacuum was thus created above the boiler, whilst the full pressure of the atmosphere was exerted beneath it. This would cause the boiler to rise from its seat, provided the atmospheric air did not at the same instant rush into it, in which case the bottom would be pressed downwards, and the upper part being torn asunder, as had been described, would then rise into the air with the elastic fluid.

When it was considered that the superficial area of these boilers was about 60 square feet; that the pressure of the atmosphere was nearly 1 ton per square foot, and that the weight of the boilers was only 8 or 10 tons, it would be apparent that the cause was quite adequate to the effect, with a very partial vacuum or inequality of atmospheric pressure. The case was analogous to those in which light bodies were raised into the air by whirlwinds.

He referred also to two cases of an equally uncommon nature, which had lately come under his notice professionally, and which he considered to arise chiefly from inequality of atmospheric pressure.

Plymouth Breakwater.

The first occurred at the Plymouth Breakwater during the great storm in the month of February 1838, when several of the largest granite blocks, weighing from 3 to 8 tons each, composing the surface or pavement of the breakwater, which, although squared and dove-tailed into the structure, and embedded in excellent cement to the extent of their whole depth, and thus forming a solid mass, were torn from their positions, and projected over the breakwater into the Sound. He attributed this to the hydrostatic pressure exerted beneath the stones, at the moment when the atmospheric pressure above had been disturbed by the masses of water suddenly and rapidly thrown upon the surface of the breakwater. Blocks of stone were thus often carried to a great distance, not so much by the waves lifting them, as by the vacuum created above them by the motion of the water, which exerted at the same time its full pressure from below.

Eddystone Lighthouse.

The other case occurred during a storm in the year 1840, when the sea door of the Eddystone Lighthouse was forced outwards, and its strong iron bolts and hinges broken by the atmospheric pressure from within. In this instance he conceived that the sweep of the vast body of water in motion round the lighthouse had created a partial and momentary, though effectual, vacuum, and thus enabled the atmospheric pressure within the building to act upon the only yielding part of the structure.

A letter was read from Mr. Edward Alfred Cowper, describing some experiments on the use of maroons as signals on railways.

Signals for Railways.

The maroons are either small tin cases, or carcases of brown paper, charged with from ⅛ oz. to 2 oz. of gunpowder, mingled with which are four of "Jones's Prometheans," which are small glass tubes, each containing a drop of sulphuric acid; the tubes are surrounded with chlorate (hyper-oxy-muriate) of potassa, and are each enveloped in a strip of paper.

In the event of an accident occurring, which renders it necessary to give notice that an approaching train should be stopped at a given point, two or more of these maroons are fastened upon the upper surface of the rail by the strips of lead attached to them. The wheels of the engine, in passing over them, crush the glass tubes of the "Prometheans," the sulphuric acid inflames the chlorate of potassa, and causes an explosion of the gunpowder, which is distinctly heard by the engine driver, who immediately shuts off the steam, and puts down the break.

Mr. Gregory.

Mr. C. H. Gregory had permitted several trials to be made with these maroons on the Croydon Railway.

An engine was driven at full speed with a number of empty waggons attached to it, and with the steam blowing off to create as much noise as possible, yet the explosion of even half a drachm of gunpowder was distinctly perceived: he considered the invention to be practically useful.

April 6, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: George Thomas Page, and Robert Charles May, as Associates.

"Experiments on the strength of Iron Girders." By Thomas Cubitt, Assoc. Inst. C. E.

Strength of cast-iron girders.

This communication gives in a tabular form the results of experiments upon upwards of sixty pairs of cast-iron girders, varying in length between 7 feet 6 inches, and 27 feet, with corresponding depths, and of all the forms usually adopted for beams for buildings. They were proved in pairs by a hydraulic press placed between them, the ends being retained by wrought-iron ties. The deflexion was noted at each increase of pressure, and in many instances the beams were fractured.

Sketches of the girders, and of the apparatus used for proving them, accompanied the paper; from them five drawings have been made at the Institution to facilitate a reference to the information contained in the communication.

"Description of an improved Level and Stand." By G. Townsend.

Improved Level.

This improvement being intended to procure a firmer basis and greater facility of adjustment than by the ordinary level, the author has adopted the principle of the triangular plate, with three levelling screws. In the ordinary instrument, with two pairs of screws, it has been found that the antagonist screws, besides being apt to wear unequally, and to indent the lower plate, are sometimes bent, and thus cause an unequal action upon the upper plate. To obviate these defects, the screws in the tripod level are made to work into inverted cones, which are fixed in the three grooved arms of the stand head; the weight is more equally distributed, and the telescope more speedily brought to a level.

The telescope is fixed to the levelling plate by an upright limb, and to this is added a small longitudinal cross level, as in Gravatt's instrument. In the improved stand, each of the legs is attached to two arms of the lower tripod plate, by which means a firmer basis is obtained. The usual locking plate, to secure the levelling screws, is also attached to this instrument, and kept in place by a spring catch; there is also a metal ring fixed on the upright limb, above the arms, and which falls into three spring catches in the table plate, by which any derangement from accidental violence, or in removal from one station to another, is effectually prevented.

A small circular spirit level is fixed in the stand in order to adjust it before the instrument be placed on it, by which means the labour of adjustment is considerably abridged.

April 20, 1841.

The PRESIDENT in the Chair.

"Experiments for determining the position of the neutral axis of rectangular beams of cast and wrought iron and wood, and also for ascertaining the relative amount of compression and extension at their upper and under surfaces, when subjected to transverse strain." By Joseph Colthurst.

The neutral axis of beams.

These experiments were undertaken in consequence of the difference of opinion which has long existed respecting the position of the neutral axis of extension and compression of iron and wood.

First experiments.

Two series of experiments were made to determine this point by cutting through the centre of each of a set of eight girders, each 6 feet 6 inches long, 5 inches deep, and ½ inch thick, the first to the depth of ½ an inch, the second to the depth of 1 inch, and so on, to the eighth girder, in which only 1 inch of metal remained unsevered. The spaces cut out were then filled with carefully fitted wrought-iron keys, and the girders were broken by the application of weights, in the expectation that these weights would be some indication of the neutral point of each girder. The results were, however, so irregular, that no satisfactory deductions could be drawn from them.

Second experiment.

The next attempt was made in the manner suggested by the late Mr. Tredgold, by drawing two fine lines, 2¾ inches apart, on a polished surface at right angles to a girder, in the middle of its length; it was then subjected to strain, and dimensions were sought to be taken to determine where their divergence and convergence commenced, but the differences were too small to be susceptible of accurate determination, otherwise than by a fine micrometrical operation, which at the time the author had not an opportunity of applying. The following plan was therefore adopted.

Third experiment.

In the side of a cast-iron girder, 6 feet 6 inches long, 7 inches deep, and 1 inch thick, a recess was planed at the centre, 3 inches wide by ¼ inch deep. This was filed up very true, and fourteen small bars of wrought iron, with conical ends, were placed in it at regular distances of ½ an inch apart. These bars were of such lengths as to hold sufficiently tight to carry their own weight, and yet that the slightest touch should detach them. The girder was then subjected to strain. The supports were 6 feet apart; with a strain equal to 100 lbs., the lower bar fell out; as it was increased, they continued to drop, and with 1500 lbs. all those below the centre had fallen. The strain was then increased to 7000 lbs., but no more bars fell. The centre bar remained exactly as when put in; all those above the centre became firmly fixed, and were evidently under considerable compressive force. The strain was then gradually taken off, and all the bars above the centre fell out, their ends having become compressed by the sides of the recess pressing on them; they were of course too short when the girder resumed its former condition, and the recess its previous width. These experiments were repeated several times, with pieces of fine wire and dry lance-wood charred at the ends.

The result in every case showed that the *neutral axis* of extension and compression was certainly situated within $\frac{2}{10}$ths of an inch of the centre.

Another experiment was still more decisive. A girder 9 feet 6 inches long, 8 inches deep, 1 inch thick, was cast with two brackets or projections on the side, each 9 inches on either side of the centre. A brass tube bar, with circular ends and a sliding adjustment, was fixed between the brackets, which had been filed true. The clear bearing was 7 feet 6 inches; a strain of 50 lbs. was sufficient to cause this bar to drop out; and with 250 lbs. the whole effect of the previous experiment was produced. The tube, when placed loosely, 1 inch above the centre, was held fast by a strain of 1000 lbs.

Wrought iron.

Similar experiments were then made on wrought iron, with precisely the same results, shewing that the neutral axis, if not actually situated at the centre, was nearly identical with it.

Wood.

A similar series of experiments, made upon wood beams, gave exactly the same results as regarded the position of the neutral axis.

From all the foregoing experiments, the author concludes that the neutral axis of extension and compression in rectangular beams of cast and wrought iron and wood, is situated at the centre of their depth, when those beams are subjected to transverse strains.

Extension and compression.

Experiments were also instituted to ascertain the amount of extension and compression of cast and wrought iron and wood.

Cast iron.

Upon a bar of cast iron, 3 inches square, and 9 feet long, two strips of thin hoop iron were attached, the one on the upper, and the other on the lower side, each strip being fastened to the bar at one end only, while the other end was left free; any change which occurred in the length of the surface to which it was applied was clearly indicated. The differences were recorded by very fine lines on a polished surface. The strips were 7 feet 6 inches long, and were bound to the whole length of the beam by bands of fine wire, wound round and enclosing them at every 9 inches; the beam was then subjected to strain, and the following results were obtained:—

Weight. lbs.	Deflection. inches.	Compression. inches.	Extension. inches.
1000	0·22	. . .	. . .
2000	0·45	0·04½	·04½
3000	0·65	0·06	0·06
4000	0·87	0·08	0·08
5000	1·20	0·11	0·12
6000	1·50	0·13	0·14

6240 the beam broke; good iron; showing a good clear fracture.

It will be perceived, that until rather more than two-thirds of the breaking weight was put on, the amounts of extension and compression did not sensibly differ, but between that point and the breaking weight, extension yielded in a higher ratio than compression.

Wrought iron.

Similar experiments were next made on bars of wrought iron, 2½ inches square; the supports were 13 feet 6 inches apart; and the strips of hoop iron were 12 feet long.

Weight. lbs.	Deflection. inches.	Compression. inches.	Extension. inches.	Elasticity impaired.
500	0·55	0·03	0·03	. . .
1000	1·55	0·06	0·06	. . .
1280	1·45	0·07	0·07	0·15
1560	1·85	0·08	0·08	. . .
1800	2·20	0·09	0·09	. . .
2000	2·70	0·11	0·11	0·65
2280	4·15	0·18	0·19	2·05

With this weight the beam was permanently bent, and its elasticity nearly destroyed.

These experiments showed that, differing from cast iron, the amounts of extension and compression in wrought iron continue to be equal up to the complete destruction of the elasticity of the beam.

Fir battens.

The amounts of extension and compression in rectangular beams of fir timber, when subjected to transverse strain, were next determined; the manner of proceeding was precisely the same as in the preceding experiments.

A batten, 4 inches by 3 inches, with the supports 8 feet 2 inches apart, and with strips 7 feet 6 inches long, when subjected to transverse strain, gave these results:—

Weight. lbs.	Deflection. inches.	Compression. inches.	Extension. inches.
500	1·10	0·12	0·12
1000	2·30	0·24	0·24

From these experiments on the amount of extension and compression of cast iron, measured at the under and upper surfaces of rectangular beams, subjected to transverse strain, the author assumes, that within limits which considerably exceed those of elasticity, and equal to at least two-thirds of the breaking weight, there is no sensible difference between the amounts of compression and extension, and that as the breaking point is approached, extension yields in a higher ratio than compression, and gives way first. Results. Cast iron.

It would appear certain that up to the point when the elasticity of wrought iron is completely destroyed, and the beam is bent, the amounts of compression and extension continue exactly equal, and it is therefore probable that this equality would continue to the last. Wrought iron.

It is clear that the amounts of extension and compression up to three-fourths of the breaking weight do not sensibly differ in fir battens, but that as the ultimate strength of the beam is approached, compression yields in a much higher ratio than extension, and may be actually seen to give way first. Fir battens.

He states also, that the amounts of extension and compression are in direct proportion to the strain, within the limits of elasticity, and that even after those limits are greatly exceeded, and up to three-fourths of the strength of a beam, they do not sensibly differ.

The apparatus with which these experiments were made was exhibited, and presented by the author to the Institution.

Mr. Donkin eulogised the novel and ingenious manner in which Mr. Colthurst had conducted the experiments, which he considered to be highly satisfactory. They not only determined the position of the neutral axis of the beams experimented upon, but showed also the relative amounts of compression and extension, so as to demonstrate that the elasticity of a body was the same in compression as in extension. These experiments also confirmed the correctness of Tredgold's opinion as to the pernicious effects of attempting to produce peculiar forms in beams by cambering and inserting wedges into their upper sides. Mr. Donkin. Cambered beams.

Mr. Vignoles reminded the meeting of the discussions which had taken place relative to the position of the neutral axis in the Railway Bars, which had the upper and under tables similar; it was contended that the neutral axis was situated close beneath the upper lip, or table of the rail, whereas, if Mr. Colthurst's mode of experimenting had been adopted, a different and more correct result would have been arrived at. Mr. Vignoles. Railway bars.

Mr. Cubitt. Mr. Cubitt accorded great merit to Mr. Colthurst for the experiments, which had determined the question as regarded rectangular beams. It appeared that no attempt had been made to use the same mode of proceeding with beams of irregular figures; in them, therefore, it might be concluded, that the neutral axis would be found in the centre of gravity of the section of the beam.

Mr. J. Horne. Mr. J. Horne remarked, that these experiments perfectly accorded with those which he laid before the Institution in 1837. His object had been to show that the neutral axis was always in the centre of gravity of the section, as well as to determine the figure which should resist the greatest amount of pressure with a given quantity of materials: the strongest form was shown to be a prism, placed with the base upwards, and the same figure reversed was the weakest; the strength of the former figure exceeded that of the latter by at least one-third.

April 27, 1841.

The PRESIDENT in the Chair.

"Memoir of the Montrose Suspension Bridge." By J. M. Rendel, M. Inst. C. E.

Montrose Suspension Bridge. Old wood bridge. Previous to the year 1792, the passage of the River Esk at Montrose was effected by common ferry boats; at that period an act of parliament was obtained for the construction of a wooden bridge, with numerous arches, or rather openings formed by beams, supported upon piles, with stone abutments at either end: the action of the tide undermining the piles, and the usual progress of decay causing great expense for repairs, it was decided in the year 1825, to erect a Suspension Bridge, the iron-work of which was contracted for by Captain Samuel Brown, R.N., for the sum of £9430., and the masonry of the towers for £9080. The total cost being £18510., exclusive of the land arches and approaches; those of the old bridge being preserved for the new one.

Suspension bridge.

Dimensions. The dimensions of the new bridge were—

	Feet
Distance from centre to centre of the towers . .	432
Deflection of the chain or versed sine of the catenary	42
Length of the suspended roadway	412
Width of ditto	26
Height of ditto above low water	21
Ditto of the towers above ditto	68

Base of the towers at the level of the roadway 40 ft. by 20

Archways through the towers, 16 ft. wide and 21 ft. high.

The towers were built of red sandstone ashlar, raised on a base of the same material, carried upon piles.

Construction.

There were two main chains on each side, arranged above each other in parallel curves, 12 inches apart. Each chain was composed of four bars of iron, 5 inches wide by 1 inch thick, and 10 feet long, united by short plates, and strong wrought-iron pins. The roadway was suspended to these chains by perpendicular rods, 1¼ inch in diameter, attached at intervals of 5 feet, alternately to the upper and lower lines of main chains, at the joints, which were arranged so that those of the upper chain should be over the long bars of the lower one; at the lower end of each suspending rod was a stirrup, which received and carried the cast-iron bearers for supporting the roadway.

Upon these bearers was laid and rivetted longitudinally a flooring of fir planks, 3 inches thick, and well caulked; upon this a sheathing of fir, 1¼ inch thick, was placed transversely, and spiked to the lower planks; over all was spread a coating of about 1 inch thick of fine gravel and sand, cemented with coal tar.

The suspending rods were without joints. The main chains rested upon detached cast-iron saddles, built into the masonry of the towers, and passing down at either extremity were secured behind cast-iron plates in masses of masonry, 10 feet under ground.

The construction was commenced in September, 1828, and was finished in December, 1829, a period of only sixteen months.

Accident to the bridge.

On the 19th of March, 1830, about seven hundred persons assembled on the bridge to witness a boat race, when one of the main chains gave way, and caused considerable loss of life. The injury was speedily repaired, but a careful survey of the structure was ordered, and it was discovered that the intermediate or long links of the chains bore so unequally upon the saddles as to be bent and partially fractured. Mr. Telford, who was consulted on the subject, proposed the addition of two other main chains, placed above the original ones, and having the same curve, so as to increase the sectional area 40 inches—thus giving six chains of 20 inches area each, instead of four chains, as originally constructed.

Mr. Telford's advice.

Mr. Rendel's Report.

Mr. Telford's decease occurring at that period, the author was instructed to report upon the state of the bridge, and advise such alterations as he judged to be necessary.

After a minute personal inspection he concurred in Mr. Telford's idea of the necessity of increasing the strength of the bridge, but instead of augmenting the number of the chains, he advised the addition of two bars in width to each of those existing, by which means the required strength might be gained. He was led to this by an opinion that, in all cases, it is desirable to have as few chains as possible.

It appeared that there had been but little precision in the workmanship of the chains; for on releasing them they immediately became twisted; thus showing that all the links had not a true bearing. On taking them apart, many of the traversing pins were found to be bent, and some of them were cut into, evidently by the friction of the links. This was to be rectified, and new saddles of a different principle and stronger form were recommended: also, that those parts of the chains which rested in the saddles should be entirely composed of short plates. Additions to the masses of masonry holding the chains were likewise deemed advisable.

Alterations advised.

Between the years 1835 and 1838, all the principal works, with many minor improvements, were executed.

The platform.

In the author's report on the state of the bridge, he noticed what he deemed defects in the construction of the roadway, but as there was no positive symptom of failure, it was allowed to remain. He conceived, that in the anxiety to obtain a light roadway, mathematicians and even practical engineers had overlooked the fact, that when lightness induced flexibility, and consequently motion, the force of momentum was brought into action, and its amount defied calculation.

Partial destruction of the roadway.

On the 11th of October, 1838, the roadway of the bridge was destroyed by a hurricane, the effect of which upon this structure is the subject of a paper by Colonel Pasley, published in part 3, vol. 3, of the Transactions of the Institution C. E. To that account the author refers for the principal details, only adding, that on inspecting the bridge, he found the chains, the saddles, and the fastenings or moorings, quite sound; the principal portion of the roadway had been completely carried away, and the remainder much injured. He then gives some account of the undulatory motion observed during the storm. This motion was greatest at about midway between the towers and the centre of the roadway; but the waves of the platform did not coincide with those of the chains, either in magnitude or in order; no oscillatory motion was perceived either in the roadway or in the chains, although particular attention was directed to them.

Undulatory motion.

Cause of the fracture of the platform.

It appears that the centre of the platform fell in a mass. This the author attributes to the failure of the suspension rods, which, having no joints, were twisted off close to the floor by the undulatory motion.

A similar occurrence at the Menai Bridge* induced Mr. Provis to adopt the joints in the suspension rods, which the author had previously introduced at the Montrose Bridge.

The author had long been convinced of the importance of giving to the roadways of suspension bridges the greatest possible amount of stiffness, in such a manner as to distribute the load or the effect of any violent action over a considerable extent.

The platforms of large bridges, in exposed situations, are acted upon in so many different ways by the wind, that he had an objection to the use of stays or braces to counteract movements which ought rather to be resisted by the form of the structure.

Trussed framing.

Holding such opinions, he determined to adopt a framing which, although connectedly rigid in every direction, should nevertheless be simple, composed of few parts, capable of being easily renewed; should distribute its weight uniformly over the chains, not be subject to change from variation of temperature, and not augment the usual weight of suspended platforms.

General alterations.

The details of the alterations, and general repair of the bridge, are then given; a few may be mentioned.

Suspending rods.

An entirely new set of stronger suspending rods was introduced; they were $1\frac{5}{8}^{\text{ths}}$ of an inch in diameter down to the flexible joint at the level of the platform; below that point the diameter was increased to $1\frac{3}{4}^{\text{ths}}$ of an inch, and a strong thread was cut on to the lower end, so as to adjust them to the requisite lengths.

Bearers of roadway.

In the place of the cast-iron bearers cross beams were substituted, composed of two Memel planks, 13 inches deep, $3\frac{1}{2}$ inches thick, bolted together, and trussed with a round bar $1\frac{1}{8}^{\text{th}}$ inch diameter; every sixth beam had a deep trussed frame on the under side, so as to give great stiffness. Above and beneath the cross beams, on each side of the carriage way, were bolted two sets of longitudinal timbers, four in each set; they were further united by cast-iron boxes, at intervals of 10 feet; and the ends were secured to beams of English oak, built into the masonry of the towers. A curb of Memel timber, 11 inches by 6 inches, was attached to the ends of the cross bearers, and extended the whole length of the platform.

The footways.

The planking of the footways was composed of narrow battens, 2 inches thick, laid transversely from the inner longitudinal beam to the outer curb piece, with an inclination or drip of $1\frac{1}{2}$ inch in 5 feet.

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* *Minutes of Proceedings*, Inst. C. E. 1841, pages 58 & 75.

The carriage way. The carriage way was formed of four thicknesses of Memel plank; the two lower layers, each 2 inches thick, were placed diagonally with the transverse beams, crossing each other so as to form a reticulated floor, abutted against the longitudinal beams; they were firmly spiked to the beams, and to each other, at all the intersections, and upon them was laid and spiked a longitudinal layer of Memel planking, 2 inches thick. Over the whole was fixed, transversely, a layer of slit battens, $1\frac{1}{4}$ inch thick. Each layer was close jointed and caulked, and the upper one was laid in a mixture of pitch and tar. A composition of fine gravel and sand, cemented with boiled gas tar, was laid over the whole, to the thickness of 1 inch, forming the road track.

Diagonal trussed frame. To add to the stiffness afforded by this construction, the author caused to be passed through the spaces between the pairs of longitudinal beams, a series of diagonal truss pieces of Memel timber, 6 inches square, with their ends stepped into the cast-iron boxes, which, at every 10 feet, grasp the beams. On the other ends of these diagonal truss pieces, cast-iron boxes were fixed, which received the straining pieces, placed 3 feet 6 inches above, and the same depth below, the roadway: an iron screw bolt, $1\frac{1}{4}$ inch diameter, at every 10 feet, and a contrivance of wedges in the cast-iron boxes, enabled any degree of tension to be given to the framing.

The roadway was thus stiffened by two of the strongest kinds of framing, in parallel lines, dividing the carriage way from the footpaths; it was deemed preferable to disconnect them from the suspending rods, and, by bringing them nearer together, to avoid a twisting or unequal strain. The whole formed a compact mass of braced wood work, the diagonal planking giving the horizontal stiffness, and the two trussed frames insuring the vertical rigidity.

Weight of roadway. The weight of the new roadway was—

	Tons.	Cwt.
Wood work	130	19
Cast and wrought iron about ditto . .	36	6
Wrought iron in the suspending rods .	20	14
Ditto in the fencing	8	18
Gravel concrete	30	0
Total	226	17

Or 47·5 lbs. per square foot, superficial, for the entire roadway.

The weight of the original roadway was—

	Tons.	Cwt.
Wood work	69	0
Cast iron about ditto	92	0
Wrought iron in the suspending rods .	12	9
Gravel concrete	30	0
Total	203	9

Or 23 tons less than the new roadway.

Cost.

The platform described is 412 feet long, and 27 feet wide; it cost £4026, or about seven shillings and threepence per superficial foot.

The works were completed in the summer of 1840; the bridge has borne without injury the gales of the last winter; and the stiffness of the platform has given confidence in its strength to all who have examined it.

Five elaborate drawings of the bridge, giving all the details of its construction on a large scale, accompanied this communication; they were presented by Mr. Page on his election as an Associate of the Institution.

Mr. S. Seaward.

Mr. Seaward agreed with Mr. Rendel in the advantage of reducing the number of suspension chains, and thus rendering the whole construction as simple as possible. The trussed framing, which appeared to be the main feature of this bridge, was particularly deserving of commendation, as it imparted a degree of stiffness to the platform which had not hitherto been attained in other cases, although it was demonstrated to be the best method of preventing the undulation which was so prejudicial to the suspension bridges.

Mr. Rendel.

Mr. Rendel had, on a previous occasion,* explained his view of the action of wind upon the platforms of suspension bridges, and of the necessity of a certain degree of stiffness in the construction; this he conceived would always be better attained by having a simple well-trussed framing to prevent undulation, than by the application of braces or stays to check either undulation or oscillation—the latter being in his opinion only the result of the former.

He would now only insist more forcibly upon those points. The roadway should be so stiff as to prevent as much as possible all tendency to motion, because it added to the natural decay of every part of the structures; for instance, he found on taking down the chain of the Montrose Bridge, after seven or eight years' wear, that the pins of the links were cut some depth into; demonstrating how great had been the amount of motion among the links. In constructing suspension chains, after this experience, he should be inclined to abandon the circular form for the pins, and forge them of a long oval shape in their transverse section; making the apertures in the links by drilling two holes, and cutting out the metal between them with a machine; this form of pin would allow sufficient play for the necessary curve of the chain, while the pin itself would be stronger, would weaken the link less than the large circular hole, and would be less expensive to manufacture. He disapproved of all the complicated contrivances for allowing expansion of the main chains; he had found that plain saddles of proper form were quite sufficient to permit the expansion of the back chains, which was all that required attention.

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* *Minutes of Proceedings*, Inst. C. E. 1841, page 79.

Mr. Palmer. Mr. Palmer mentioned, on the authority of Mr. Chapman, the destruction of a suspension bridge in America, caused by the sudden passing of a drove of cattle when frightened. This was peculiar, as it always had been considered that an irregular motion was innocuous, but that when any regular impulses were communicated, there was danger of fracture of the bars.

Mr. Vignoles. Mr. Vignoles eulogised this excellent communication for the practical conclusions which it contained. Mr. Rendel had materially assisted in affording facility of communication by the introduction of the floating bridges, in communication with railways, and it was not difficult to foresee that, by carrying out the system of adapting well-trussed framings to the platforms of suspension bridges, sufficient rigidity would be attained for locomotive engines and carriages on railways, to traverse rivers or ravines by means of these bridges, instead of by costly viaducts or heavy embankments.

Mr. Rendel. Mr. Rendel saw no difficulty in giving any required amount of rigidity to the platforms; it was only necessary to increase the strength of the framing, to enable the roadway to bear with perfect safety the passage of an engine and a train of carriages.

The President. The President directed the attention of the Members to what he considered the most valuable part of this interesting communication—the detection of the errors in the original construction of the bridge. This was the most useful class of papers which Members could present to the Institution, and they were particularly valuable when they were illustrated by such complete drawings as those now communicated by Mr. Page on his election. He hoped this example would be extensively followed.

He mentioned, that an attempt had been made to carry a railway across the Tees by a suspension bridge, but it had been abandoned.

Mr. Rendel.

Mr. Rendel understood that the weight of the trains had so stretched the chains, or rather forced the moorings of the back chains of the bridge over the Tees, that the platform sunk in the centre so as to prevent the passage of the carriages; piles had therefore been driven beneath each bearer of the roadway, and the chains now remained merely to show that it had formerly been a suspension bridge.

May 4th, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: George Rennie, as a Member; John Smythe Robinson, as a Graduate; William Greener, and Robert Alexander Maingy, as Associates.

"Supplementary Account of the Use of auxiliary Steam Power, on board the 'Earl of Hardwicke' and the 'Vernon' Indiamen." By Samuel Seaward, M. Inst. C. E.

Auxiliary steam power.

The advantage of the employment of auxiliary steam power, on board large sailing ships, had been shown by the author in a former paper (p. 63); it was now further exemplified by the result of the recent voyages of the "Earl of Hardwicke" and the "Vernon."

'Earl of Hardwicke.'

The former vessel, of 1000 tons burthen, with one engine of 30-horse power, effected the voyage from Portsmouth to Calcutta in 110 days, a much longer time than usual; but still with an advantage of 29 days over the "Scotia," a fine vessel of 800 tons, which sailed one week before the "Hardwicke," and arrived 22 days after her. During the voyage, the "Hardwicke" used her engine 364 hours, and was propelled by it 946 knots; an average of nearly three knots per hour: while in a calm, with the ship steady, she made five knots per hour. The total consumption of fuel was 90 tons.

The 'Vernon.'

The "Vernon," which sailed one month after the "Hardwicke," made her passage to Calcutta in 97 days; passed the "Scotia," and arrived 7 days before her, gaining 42 days upon her during the voyage. The "Vernon's" consumption of fuel was also 90 tons, but the copy of her log not being arrived, the number of hours during which steam was used, could not be ascertained.

The 'India.'

The "India" steam ship, of 800 tons burthen, with engines of 300 horse power, had not arrived at Calcutta, although she had been out 109 days, so that the "Vernon," with only auxiliary steam power, had already gained 12 days upon her.

Comparison of expense.

The comparison between the advantages of these two vessels, in point of expense, is then fully entered into, and shows a saving of £3733. in favour of the "Vernon," on a single voyage, while she gained at least 12 days upon the "India," in point of time.

This communication is accompanied by a copy of the log of the "Earl of Hardwicke," and by letters from the captains of that ship and the "Vernon," speaking in the highest terms of the assistance of the steam power in certain parts of the voyage.

"Description of an improved Levelling Staff, and a modification of the common Level." By Thomas Stevenson.

Improved Levelling Staff.

In enumerating the advantages of this improvement, the author passes in review the different levelling instruments in general use. He describes the self-reading staff as very useful, but ill adapted to the extreme accuracy generally necessary in the operation of levelling.

He considers the running level to be equally inadequate, from the difficulty of attaining a precise coincidence in the cross wires and the vane line.

On the authority of Mr. Simms, in his Treatise on Mathematical Instruments, he states that these evils are in some measure remedied by Mr. Gravatts' rod, but he still considers that instrument to be imperfect. He therefore caused a rod to be constructed by Mr. Adie, of Edinburgh, the vane of which is adjusted by tangent screws. The range of this staff is 12·7 feet, and the graduation so perfect as to be read by verniers to the $\frac{1}{1000}$th of a foot. On the right of the lower portion of the rod there is a screw, which, on being tightened, clamps the vane, and on the opposite side is the tangent screw for adjusting it. Supposing in practice that the level line strikes the lower half of the rod, the vane and screw are then easily moved by the hand to within $\frac{1}{4}$ inch of the point, and then, by means of the tangent screw, perfect correctness can be attained.

After having sent his communication to the Institution, the author learnt from the Secretary that adjusting screws had already been used in two other levelling staves by Captain Lloyd and by Mr. Bunt. He was not, however, aware of this circumstance, and he considers that these instruments, being adapted only for scientific purposes, are hardly suitable for the ordinary use of the Engineer.

Improved Level.

The author also introduced a ball and socket joint at the junction of the legs of the common level, retaining at the same time the parallel screw plates, and adding beneath a small sluggish spherical level. By these means the surveyor is enabled to station the instrument, regardless either of the inequalities of the ground, or of the inclination of the telescope to the horizon.

When in use the clamp of the ball and socket is released, and the head of the level moved until the bubble shall be in the middle of the circle; the socket screw is then clamped, and the telescope brought to the absolute level by means of the parallel screws. It becomes thus unnecessary to move the legs of the instrument when once fixed.

"An improved mode of Paving Streets." By Edward Lomax, Assoc. Inst. C. E.

Improved Pavement.

In this communication the author proposes to remedy the danger and difficulty of stopping or turning horses during wet or frosty weather on wood pavement. His plan is, that a breadth of 2 feet 6 inches, near each side of the street, should be paved with stone, for the horses to travel upon, the carriage wheels still running upon wood; by which means all the advantages of that kind of pavement would be preserved without risk to the horse. In very wide streets a centre track might also be paved with stone.

By this plan the labour of the horse would be greatly diminished, a considerable portion of his power being now lost, because the wood pavement is less favourable for the footing of the horse than for the motion of the wheels.

The author is therefore of opinion, that granite pavement for the horse to travel upon, and wood pavement for the wheel way, would form a road on which the horse would work with the least loss of power, and the greatest safety.

A model of the proposed improvement accompanied the paper.

Specimens of Sea-weed used for sea defences.

Mr. Macneill presented three specimens of the Sea-weed with which the Sea Embankments are formed in some parts of Holland.

He described one of the specimens in its natural state as resembling the weed which is collected by the peasantry on the western and north-western shores of Ireland, and used by them for bedding.

Embankment at Niewe Diep.

The second specimen was taken from near the bottom of the embankment at Niewe Diep, the entrance of the grand canal near the Helder. It was much compressed, but elastic.

The third specimen was less compressed; it was taken from the same embankment, above the range of the ordinary neap tides.

Peat sods for sea defences.

This embankment is of considerable width, and has very little slope towards the sea: the work appeared extremely compact and solid; he saw it when a heavy sea was running in, and each action of the waves against it caused a vibration throughout the whole mass—thus proving the elasticity of the material when consolidated, and corroborating the Hon. Mr. Stewart's description of the same effect upon the peat sod embankments, in a paper shortly to be laid before the Institution. Mr. Macneill spoke with confidence of the efficiency of the peat sod for sea defences, as he had used it with good effect, although at present only to a limited extent.

The attention of the Members of the Institution was especially directed to the sea embankments of Holland, as affording excellent study and ample materials for communications for the meetings.

May 11, 1841.

The PRESIDENT in the Chair.

William Lewis Baker was balloted for and elected a Graduate.

"On Lead Sheathing for Ships." By J. J. Wilkinson.

Lead sheathing for ships.

The commencement of this communication, which is the continuation of the paper on the "Wood Sheathing of Ships," which was read March 23d (page 98), examines in great detail the various uses to which metals were put in the earliest period of which any record exists, and then it traces the first application of lead to the protection of shipping.

There are very early instances of ships and vessels being covered with lead.

Ancient vessels.

In the 15th century, a boat, 30 feet in length, was found in the Mediterranean sunk in 12 fathoms water; it was built of cypress and larch. The deck was covered with paper and linen, and over all with plates of lead, fastened with gilt nails; this covering proved so impervious to moisture, that parts of the interior were perfectly dry. It is supposed to have lain there above 1400 years.

A Roman ship was also found sunk in the Lake of Nemi. The hull was of larch; bitumen had been applied to the outside, over which was a coating of a reddish colour, and the whole covered with sheets of lead, fastened by gilt nails. The interior had a thick coating of cement made of iron and clay. The seams of the planks were caulked with tow and pitch.

Ancient buildings.

Some of the ancient domes at Ephesus were sheathed with lead, and it appears that the column of Constantine at Constantinople was formerly covered with metal.

It is certain that lead mines were worked in Britain by the Romans; and long before the Conquest, plates of lead were used as coverings for ecclesiastical buildings. These coverings being designed to endure, were of very thick lead.

Water pipes.

In 1231, water was brought from Tyburn to London in pipes; but the material of the pipes has not been ascertained. In 1285, the great conduit in Cheapside was supplied with water conveyed through pipes from Paddington; these pipes are expressly stated to have been of lead. It has, however, been averred, that lead pipes for conveying water were first introduced by Robert Brook, in the reign of Henry the Eighth.

Lead sheathing used in Spain.

Sheet lead was used in Spain and Portugal for sheathing ships, and for covering the rudders, long before it was employed in England. It was used in Holland in 1666, and at Venice in 1710.

Introduced by Sebastian Cabot.

It is probable that we are indebted to Sebastian Cabot for its introduction into England; it is stated in his Memoirs that he first saw it used in 1514; he was then in the service of the king of Spain, which he entered in 1512, and was appointed pilot major; he afterwards returned to England, and in 1553 was named by Queen Mary, "Governor of the Mysterie and Company of Merchant Adventurers, for the discovery of Regions, Dominions, Islands, and Places, unknown."

Three vessels were fitted out for this purpose, under the command

Origin of the Russia Trade and of the Whale Fishery.

of Sir Hugh Willoughby, one of which was sheathed, or at least partly so, with thin plates of lead, then first mentioned as an "ingenious invention." This expedition was unfortunate—Sir Hugh Willoughby, with the crew of two of his ships, being frozen to death; one of the commanders, and his crew, alone escaped. This expedition was the origin of the trade to Russia, and of the Spitzbergen Whale Fishery.

In the reign of Elizabeth a patent was granted to one Humphrey, for melting lead, but was afterwards recalled, the plan not being new.

Milled lead

It appears that, up to about 1670, cast sheet lead was used for sheathing; at that time milled lead was invented, and a patent for milling lead was granted to Sir Philip Howard and Francis Watson; by this process the inequalities, as well as the defects from air holes, in the former mode of manufacture, were remedied; the whole surface was rendered smooth and uniform, and the weight greatly reduced. This invention met with much opposition from the plumbers, who averred that it could not be durable; an offer was therefore made on the part of the Milled Lead Company, to keep in repair during forty-one years all milled lead of the weight of 7 lb. per square foot, at the rate of five shillings annually per each hundred pounds worth in value.

Used in the Royal Navy.

One of the earliest vessels in the royal navy thus sheathed, was the Phœnix, a fourth-rate. This was done at the express command of Charles II. This vessel made two voyages to the Straits, apparently for the express purpose of testing the new invention, and on her return in 1673, was careened at Deptford, and personally inspected by the King. An order was then issued that his Majesty's ships should in future be sheathed only with lead, excepting by especial order from the Navy Board. It appears that about twenty ships of the royal navy were consequently sheathed with milled lead, and fastened with copper nails.

Destruction by voltaic action.

Even the royal protection could not save this invention from cavillers, so that, in 1677 and 1678, complaints were made by Sir John Narborough and Sir John Kempthorne, that the rudder irons of the Plymouth and the Dreadnought were so much eaten, as to render it unsafe for those vessels to proceed to sea; these complaints were repeated in 1682.

The patentees maintained, on the contrary, that the damage to the rudder irons could not possibly arise from their being covered with lead, as it had been the invariable practice for a great many years, to secure the iron work of ships, generally, by lead covering, and especially by capping the heads of their bolts, under water, with lead, seized to and nailed over them. Reports too in favour of the invention were made by Sir Phineas Pett, and by Mr. Betts, master builder, at Portsmouth, in which the latter stated, that lead had effectually prevented the vessels becoming what is technically termed "ironsick," meaning that the bolt-holes became so widened by corrosion, that the bolts were loosened; he recommended, however, that the lead sheathing should be stripped every seven years, on account of the decay of the oakum in the joints; declaring, too, that it became less foul on the voyage than wood sheathing, and was much more easily cleaned. These different opinions led to the issue of an Order in Council in 1682, for the appointment of commissioners to examine and report upon the alleged injury to the iron work by milled lead covering; it is probable their report was unfavourable, as it is said that the use of lead covering, fastened with copper nails, was abandoned on account of the rapid corrosion of the rudder irons. A controversy appears to have arisen on this subject, the merits of which it would be difficult to ascertain after such a lapse of years. Government, however, subsequently determined to make another trial of the value of lead covering; accordingly, the Marlborough was so sheathed, and laid up in ordinary, at Sheerness. A few years after, she was docked, at Chatham, in 1770, when it was found that the lead sheathing was covered with weeds, and the iron fastenings very much decayed; the lead was in consequence removed, and a wood sheathing substituted.

Lead sheathing abandoned.

Several patents were afterwards obtained for different mixtures of metal for this purpose, none of which seem to have succeeded, being all subject to the same inconveniences as the simple metal; among which was the influence of the sun in the torrid zone, which was said to reduce the lead, in the course of five or six years, to a calx.

Mixtures of metals.

Among these patents, for mixed metals for sheathing, is mentioned that of Mr. Bulteel, in 1693; it was found to have all the inconveniences of lead. Mr. Donithorne, in 1780, obtained a patent for sheathing, of a mixture of 112 parts of tin to 10 parts of zinc; this was also as objectionable as lead.

Patents for mixed metals.

Slade's patent for sheathing with copper laid upon lead, and the patents of Wetterstedt, and of Muntz, for mixed metals, are examined; and the author promises a continuation of the subject, with the history of copper sheathing.

"Experiments on the strength of Brick and Tile Arches." By Thomas Cubitt, Assoc. Inst. C. E.

Brick and tile arches.

In the course of his extensive building engagements, the author had occasion to construct some fire-proof floors; he therefore wished to ascertain how the greatest amount of strength could be attained, with a due regard to the space occupied, and the cost of the structure.

Two arches were built, each with a span of 15 feet 9 inches, and a rise of 2 feet.

The brick arch was 2 feet wide, and composed of half a brick in thickness, with cement.

The tile arch was 2 feet 4 inches wide, and built of 4 tiles, set in cement, forming a thickness of 4½ inches.

The spandrels of the arches were filled up level to the crown with rubble work and cement. A load of dry bricks was placed along the centre of both arches, and gradually increased at stated periods, from 12 cwt. 3 qrs. up to 160 cwt. at the end of 75 days, when the abutments of the brick arch gave way; and the tile arch broke down while loading.

The deflection at three points is given in a tabular form; and although, from the circumstance of there having been no tie bars across the arches, the experiments cannot be considered satisfactory, they are valuable, as supplying data hitherto rarely recorded.

Drawings of the arches accompanied the paper.

"Description of a Stone Bridge on the Middlesborough Railway." By John Harris, M. Inst. C. E.

Railway bridge.

The bridge described in this communication is only remarkable for the flatness of the arch, the rise being 5 feet for a span of 30 feet.

A drawing, and the specification of the cost of the work, with a schedule of prices, accompanied it.

"Description of a Bridge built of Blue Lias Limestone, across the Birmingham and Gloucester Railway at Dunhampstead." By Captain James Vetch, Assoc. Inst. C. E.

Bridge built upon a "natural centre."

The peculiarities in the construction of this bridge are, that the arch was composed of very small stones of the blue lias limestone, from three to five inches thick, and squared to about nine inches long and broad; that it was erected without the usual timber centreing, and that the mode of removing the earth centreing precluded any danger from unequal sinking in the arch.

The span of the bridge is 60 feet, with a rise of 10 feet. The material of the cutting where the bridge is situated, consisted of weak slate and clay, consequently the mode of construction was subjected to a severe test. Dimensions.

The abutments being completed to the springing height, the ground was cut away roughly to the form of the arch; seven rows of pegs were then inserted with their upper ends correctly designing the proper curve; a line of planks 3 inches thick was laid transversely beside each row of pegs, and upon them were placed lines of battens on edge, gauged to the exact profile of the bridge; the earth was consolidated, and a flooring of battens laid over all to form a true bed for the soffits to rest upon. Mode of construction.

From the absence of parallelism in the lias stones, their varying thickness, and the difficult adhesion of the mortar, it was deemed necessary to introduce seven transverse bonds of free-stone, which imparted to the whole structure a tendency to settle in the lines of the radii of the arch, and also prevented any rent in the lias masonry from proceeding to a dangerous extent; these free-stone bonds were firmly fastened with iron cramps.

The face had a batter of one in nine, from the springing to the string course, in order to counteract any tendency to bulge towards the faces, or in the line of the least resistance. The base was also extended and the crown narrowed, which gave a concave form to the string course.

The whole arch being filled in with the full depth of stone work on each springing, and the bonds of free-stone all placed, the lines of each between the second and third bonds were keyed up, and then those between the third and the centre bond, which thus apparently formed the key stone.

The earth centre was removed by cutting a heading 4 feet 6 inches wide, directly beneath the key stone, and then gradually excavating on either side uniformly towards the abutments, stopping at certain intervals to allow any settlement to take place. By proceeding thus, as successive portions of the arch were left to their own bearings, regular compression ensued, and a small portion only of the work was exposed to the risk of fracture from inequality of pressure; the rising of the haunches which generally accompanies any undue depression of the crown, appeared by this method to be entirely avoided. Earth centre removed.

The author ascribes much merit to the careful manner of keying Advantages.

in the courses, as no cracks occurred, and the settlement of the arch did not exceed 2½ inches. He conceives this experiment to have answered completely, as there was a saving of time, the expense of erecting the usual wooden centre was avoided, and the bridge was ready when the railway cutting reached it. He considers that this system may be advantageously used in many situations upon railways, and that the span may be at least double that of the bridge now described.

The communication was accompanied by three drawings, showing the details and progress of the construction.

"Description of the great Aqueduct at Lisbon, over the Valley of Alcantra." By Samuel Clegg, Jun.

Aqueduct at Alcantra

This aqueduct was founded by king John the Fifth in 1713, and completed by the Marquis of Pombal 1755. It resisted uninjured the shocks of the great earthquake in that year, although it was observed to oscillate considerably.

The most conspicuous part of the work is that which crosses the Valley of Alcantra; it consists of thirty-two arches, with spans varying from 50 to 105 feet; the crown of the centre arch is 225 feet from the ground. The length of this portion is 3000 feet.

Water sources.

The sources from which the supply of water is derived, are situated in the high ground in the neighbourhoods of Cintra and of Bellas—they are eighteen in number; one of these tributaries is conveyed by a culvert from a distance of fifteen miles.

Main duct.

The main duct into which the tributary streams empty themselves, forms a tunnel of 6 feet wide, and 7 feet high, ventilated by vertical shafts, at distances of a quarter of a mile apart.

The channels for the water are made with "drain tiles," 12 inches wide and 9 inches deep, open at the top.

After passing over the great aqueduct, the main duct runs under ground for half a mile, is carried across the "Estrada do arco Cavalho" on seven arches of 40 feet span each, on the south side of which it continues beneath the surface until it reaches the aqueduct of "Agua Livres" in Lisbon, and empties itself into the reservoir at its termination.

The reservoir.

This reservoir is 60 feet long, by 54 feet wide and 27 feet deep. The quantity of water contained in it when the author took the measurements was 64,800 cubic feet. He was unable to obtain a section of the retaining walls, but supposed them to be about 23 feet in thickness.

The pipes through which the water is distributed to the neighbouring fountains, are of earthenware and stone set in mortar. The velocity of its flow through the main duct is 75 feet per minute. The quantity discharged is about 73,000 gallons in twenty-four hours during the winter months.

Particulars of the construction.

The particulars relating to the construction of the aqueduct, the author translated from the documents preserved at the office of Public Works in Lisbon.

The foundations were laid in May 1713, and the piers, which in common with the rest of the work are of grey marble, carried up without footings. They are faced with ashlar work in courses from 1 foot 6 inches to 2 feet deep. The stones are dowelled together with bronze and iron; the centre portion of each pier is filled in with rubble masonry to within 30 feet of the top, above which it is left hollow.

Principal arch.

The voussoirs of the principal arch, to which the author more particularly refers, are carefully jointed, their thickness being on an average 8 feet at the springing, and 5 feet on the square at the crown.

The figure of the arches is pointed Gothic, the rise being $\frac{7}{10}$ths of the span.

The spandrels are of closely jointed ashlar work, about 2 feet 6 inches in thickness.

The backings are filled in with rubble quite solid; nor is there any provision made for the drainage.

Cement used.

The mortar used was made with lime from the grey marble of the neighbourhood, and sharp *sea sand,* in the proportions of one of the former to four of the latter.

Mode of raising the materials.

No mechanical contrivances were used for hoisting the blocks of marble, but they were slung upon poles from men's shoulders, and carried up a series of inclined planes to the height required.

Some of these blocks weighed upwards of three tons.

Scaffolding.

The scaffolding and inclined planes erected round the piers were of a very substantial description.

Inclined planes.

The lower parts were trussed framings formed of double Riga or Dantzic timbers 15 inches square, fastened together with trenails of teak and chesnut. The inclined planes had a rise of about 1 foot in 6 feet, with a level space at each end of the pier to serve as a resting place, where a separate gang of men received the stone block, and relieved the others.

The ends of the upright timbers of the scaffolding were not suffered to be surrounded by earth or moisture, but were placed upon blocks of stone bedded firmly and evenly upon the rock, and kept well tarred. The struts and braces retaining them were also secured from decay in the same manner. These precautions were necessary, not only from the great weight they had to support, but from the length of time they remained in use—not less it is supposed than thirty years.

The centreing for the arches was constructed by an Italian architect named "Antonio Davila."

The arches were commenced from each side of the valley at the same time, and a temporary gangway erected over them as they proceeded, so that the inconvenience of raising the material from the bed of the valley was avoided.

Centres.

The centreings were framed in their places. The cradles which supported the bearing timbers of the lower truss, were morticed into sleepers resting upon projecting stones left for the purpose; those on the same pier were secured by cross timbers so as to balance each other. The lower framings were first fixed and secured by straining pieces, and the upper portion erected afterwards in the manner of a roof principal. All the scarfs were cut vertically, fastened by trenails of teak, and but little iron was used in any part of the structure.

The striking wedges were placed under each voussoir, as in the French centreings.

As the arch rose from the springing, the crown of the centreing was loaded with stones to prevent it rising, and altering the shape of the arch.

Cost.

The cost of the entire aqueduct, which was about 21 miles long, with all the immediate and collateral works, and including the reservoir, was two millions and a half sterling.

The communication was accompanied by three elaborate drawings of the general construction and details of the aqueduct, with the manner of carrying the stones.

May 18, 1841.

The **PRESIDENT** in the Chair.

Thomas Lloyd was balloted for and elected a Member.

"On Sea Defences constructed with Peat-Moss." By the Hon. Montgomery Stuart.

Sea defences constructed with peat-moss.

In the commencement of this communication, the author refers to the early period at which the art of reclaiming land from the sea was practised, and to the extensive districts both in Britain and on the continent, where sea defences of various kinds are constantly in course of construction. He then proceeds to detail the modes suggested by the experience of many years, and practised by him in constructing sea defences in the Bay of Wigtown, for the protection of the estate of his brother, the late Earl of Galloway.

The whole of the district abounded with peat-moss, possessing many properties which rendered it, independent of its cheapness, a peculiarly valuable material for constructing embankments to resist the action of the sea. Its tough fibrous nature, its elasticity, and at the same time the rapidity with which the mass became solid, were useful qualities which he sought to take advantage of. He found also that it possessed advantages as a material for puddling; as from its absorbent nature it imbibed and retained all the moisture that approached it, and never cracked from dryness, as occurs so frequently with clay puddle. In case also of holes being made in the puddle either by vermin or external injury, they soon closed again from the elastic nature of the peat-moss, and its tendency to grow together.

Various modes of using peat-moss.

The author sometimes uses peat-moss as a puddle between two ranges of stone walls, and sometimes as a backing instead of clay-sod; but he more particularly recommends it as a backing to a stone defence parallel with the shore. For this purpose, the turf should be cut thin, placed against the bank, and the stone-work built against it; he has found this the most durable and effectual defence against the sea; the action of the waves against it even adding to its security, as from its fibrous nature it retains the silt thrown against the wall until all the interstices between the stones are completely filled, and a defence is thus formed for the wall itself by the accumulation against it.

The method he employs is to build the sea-wall of rough rubble stone, laid dry, with a slope of about two to one; the peat-moss backing, cut into blocks, rather thicker than usual, is laid in courses, well bonded and beaten together; it is thus consolidated throughout the height of the wall. Upwards of twenty years have elapsed since some of the first embankments were made on this principle; they have perfectly answered the purpose, and have been the means of effectually reclaiming a great extent of valuable land.

Warping silt.

The author also states, that he has lately been occupied in forming a defence, by warping silt, with whin or gorse kids, laid horizontally; a method which he prefers to that practised in Lincolnshire, where the kids are placed upright. He keeps the kids in their positions by means of stones laid on them, which are removed as the surface rises; fresh kids are then added, and the stones relaid.

The communication is accompanied by three sections of the sea defences, as they are executed, and by some corroborative testimony as to their efficiency, by Mr. Lewin, of Boston, who has examined and reported upon them.

Full instructions are also given for constructing the different kinds of defences mentioned.

"An account of the repairs done to the Beechwood Tunnel, upon the London and Birmingham Railway, September 1840." By Thomas M. Smith, Grad. Inst. C. E.

Repairs of the Beechwood Tunnel.

The tunnel is built of brick, is 302 yards long, and passes through strata consisting of alternate layers of rock and marle, abounding in springs of water: it was completed at the latter end of the year 1837; that winter being of unusual severity, many of the bricks were partially destroyed, owing to their containing lime, upon which the weather acted. Mr. Robert Stephenson first contemplated applying a coat of cement throughout the inside of the arch, but it was apprehended that it would not adhere, in consequence of the constant dripping of the water.

Bricks partially destroyed.

Cement first proposed.

No positive steps were, however, taken until the effects of the winter of 1839-40 had so injured the brickwork as to render further delay dangerous; it was then resolved to line the whole length of the tunnel with an interior brick arch, 9 inches thick, so as to support and insure the stability of the old work.

Tunnel lined.

Mode of conducting the repairs.

For the purpose of executing the work with facility, all the trains of carriages were diverted upon the down-line through the tunnel, and for a quarter of a mile at each end; no up-train was allowed to pass upon the single line while a down-train was in sight: a hoarding was then erected between the lines of railway throughout the length of the tunnel, to protect the workmen, and to prevent the building materials from interfering with the trains.

The internal casing of brickwork, 9 inches thick, of English bond, was then carried up one side to the height of 4 feet 9 inches above the springing: a course of York paving, 4½ inches thick, was at this point bonded into the old work, and the new work was securely attached beneath the stone bond course by iron wedges, and regular half brick toothings were inserted, at intervals of 2 feet 3 inches apart, in chases cut into the old work; by these precautions the new work was secured from being detached, and from falling upon the passing trains.

One side being finished throughout its entire length, the trains were turned upon the up-line, and the same mode of proceeding followed with the other side. A series of bearers, 6 feet apart, were then placed over head, and a close flooring laid so as to serve for scaffolding for the workmen, and to prevent the building materials from falling upon the rails. A pair of ribs were then raised upon each bearer, and keyed with a strut, 7 inches below the crown of the arch; the supporting stays were fixed, the laggans laid upon the ribs, and the brickwork of the arch was constructed in English bond throughout the whole length, and on both sides of the tunnel, simultaneously, to within 2 feet of the crown; a moveable centre, 2 feet 3 inches long, was then introduced, and the arch was closed in with two half brick rings.

Materials employed.

The whole of the work was done with blue hard burnt Staffordshire bricks, laid in cement and sand, in equal proportions, for the side walls; for the arch, up to within 15 inches of each side of the crown, two-thirds of cement, and one-third of sand; the two rings for keying up the centre or crown were laid entirely in cement, without any mixture of sand.

Drainage.

Previous to commencing the new work, a series of chases were made in the old wall, which, when closed in front by the lining arch, formed drains, 4½ inches square, terminating in the culvert beneath the centre of the railway, and conveying thither all the water, which would otherwise have separated the new from the old brickwork.

Duration of the repairs.

This work was finished, and the scaffolding removed, within the short space of forty days, by Messrs. Grissell and Peto, under the direction of Mr. Robert Stephenson, and the immediate superintendence of Mr. Dockray.

This communication was accompanied by a drawing, showing the details of the scaffolding, and the mode of construction.

"On the formation of Embankments and the filling-in behind retaining Walls." By John B. Hartley, M. Inst. C. E.

The formation of embankments.

The numerous failures of the embankments in the construction of railways, and the constant occurrence of defects in retaining walls, induced the author to offer some remarks upon the subject.

Mode of filling.

He first examines the ordinary mode of commencing the embankment at the contemplated finished level, and proceeding with the work at that height throughout, leaving the material to find its own inclination; forming the required slopes on the sides when the filling is completed. This he contends (although without doubt the most rapid mode of proceeding) is defective in principle, for the material as it is deposited forms layers or strata at such an inclination as its nature permits, and always has a tendency to slide in the direction of the slope. In such cases, as the centre sinks, the sides slide away, and having nothing at the feet to resist such a tendency, they are carried out to a dangerous extent. This is particularly the case with clay embankments, for the material is generally brought from the cuttings in large lumps, which cannot be consolidated as they are deposited: the water lodges in the interstices, keeping the bottom soft; and when it begins to subside it slides away, until it has formed itself into a slope, at which it can resist the pressure.

Footings.

To prevent this sliding, the author recommends proper footings being prepared for the sides of the embankments by cutting trenches, about 4 feet 6 inches deep, along the bottom line of each slope, and forming a 'cop' of sods or of stones, placed at right angles to the line of the slopes. These footings must be of a strength proportioned to the height of the embankment, and the whole length should be completed before the filling is commenced, that they may become solid, and the sods have grown together, before the weight is brought upon them.

Proposed mode of filling.

He advises, also, that instead of carrying on the filling in one lift, two embankments should be made, varying in height from 15 feet to 20 feet, according to the nature of the material, wide enough for two earth waggons on the top; one of them running along each side of the site of the contemplated embankment: a valley would thus be left in the centre at the junction of the two inner slopes. When they have been carried along the whole length, or to such a distance as would insure their being considerably in advance, the second or the final lift may follow. With clay or soft materials, four low lifts following each other would be advisable; with these precautions slips of the embankments would be of rare occurrence. The bottom would become solid by the passing of the weight over it, and the succeeding lift being thrown into the centre valley, must settle vertically. The subsidence, which is always in the line of inclination, would be concentrated and thrown inwards; by these means the width of the slopes would be restricted, and the work would be constructed much cheaper, there being a saving of both land and labour. Land springs, which are usually only discovered by the pressure of the weight above, would be more easily reached with the low lifts than when covered by the heavy ones.

This mode of construction has been practised by Mr. Jesse Hartley, on the Manchester and Bolton Railway, where the embankments were very heavy, and the material of the worst description: yet the work was executed in a most satisfactory manner, and the cost of the maintenance of way upon that line is quoted as being less in proportion than on any other railway in the kingdom.

Manchester and Bolton Railway.

This method may require more time, and be a little more expensive, but the author is of opinion that the trifling difference in time and cost would be amply repaid by the freedom from expense when the road was opened.

The author then examines the subject of retaining walls. He considers the method of filling towards the wall from the natural bank behind to be highly objectionable; the material lies in strata at the angle at which the deposit is made; as the quantity increases, the subsidence commences, and the earth slides downwards, throwing its whole weight against the back of the wall. The tendency to slide is frequently accelerated by the natural form of the ground upon which the earth is thrown, as it not unfrequently inclines towards the wall, in which case the pressure will necessarily be in proportion to the inclination of the slope, and the nature of the material of which the filling is composed. The wall at Hunt's Bank, on the river Irwell, is instanced as a failure of this description. The wall, about 100 feet in length, and 20 feet in height, 5 feet thick at the bottom and 3 feet 6 inches at the top, built of ashlar masonry strengthened by counterforts, was forced into the stream by the pressure of the earth behind it.

Retaining walls.

Wall at Hunt's Bank.

With proper attention to the manner of filling the different materials, a comparatively slight wall may be constructed to sustain a considerable weight of backing. The author lays down as a rule that, wherever it is practicable, all filling behind walls should be commenced at the wall, and be proceeded with from thence towards the solid ground, by which means the strata would be inclined in a similar direction: ledges or benches, either level or inclined in an opposite direction to that of the bank, should be cut in the solid ground to receive the filling, and counteract its tendency to slide. The weight should not be laid too quickly upon a new wall, and if with these precautions care be taken that the counterforts are constructed simultaneously with, and well tied into, the wall, a comparatively weak structure will bear a heavy mass of filling.

Precautions to be observed.

The author gives as an example the retaining wall constructed on the west side of Jackson's dam, near the Brunswick Graving Docks, Liverpool. This wall, although built of slight dimensions, and filled behind with material of the worst description, resisted perfectly all strain; this could only be attributed to the filling having been

Wall at Jackson's Dam.

gradually done in the manner which the author's practice leads him so strongly to recommend.

This communication was accompanied by diagrams descriptive of the mode of constructing embankments.

May 25, 1841.

HENRY ROBINSON PALMER, V. P., in the Chair.

"A Tabular Statement of the Dimensions and Proportions of Forty Iron Vessels." By Lieut. E. N. Kendall, R. N., Assoc. Inst. C. E.

Iron vessels.

The vessels, the dimensions and proportions of which are given in this communication, were all built by Mr. John Laird of Liverpool: they are adapted to a variety of purposes, so that they present but little uniformity.

The "Rainbow" and the "Glowworm" are celebrated for their speed; their proportions of beam to length are above one to six, and more than 3 tons to each horse power, which is generally assumed to be the proper ratio for sea-going steamers.

The tabular statement gives the dimensions and tonnage of the vessels, the power of the engines, the proportion of beam to length, and of tons to each horse power, the names of the owners, and the stations where the vessels are plying.

"On the Stationary Engines at the new Tunnel on the Liverpool and Manchester Railway." By John Grantham, Assoc. Inst. C. E.

Stationary engines on the Liverpool and Manchester Railway.

This communication gives a description of two pair of stationary non-condensing engines, which were constructed by Messrs. Mather, Dixon, and Co., of Liverpool, from the designs and under the superintendence of the author.

Dimensions.

The steam cylinders are 25 inches diameter, with a length of stroke of 6 feet; they have side levers like marine engines, but the connecting rods are reversed, and convey the power downwards to the machinery, which is placed in vaults cut out of the sandstone rock: upon which the beam pedestals are fixed without any framing. Cast-iron slides are used instead of the usual parallel motion, and after several years' constant use, they exhibit no marks of deterioration.

Drum wheel.

Rope.

The drum wheel is 21 feet diameter, and makes usually twenty-two revolutions per minute, when drawing up a train at the rate of 15 miles per hour; there is a groove in its periphery, at the bottom of which is wound a small cord to form a bed for the main rope to rest upon—this main rope encircles about $\frac{2}{3}^{\mathrm{rds}}$ of the circumference; it is made of the best Russia hemp, in three strands, patent shroud laid, the inner strand being composed of 40 yarns of white hemp, overlaid by 40 yarns of hemp, tarred to the point of saturation; this arrangement is found most conducive to the lightness and durability of the rope; its circumference was 6 inches, and its length, when new, was 4800 yards: in the first few weeks it stretched to the extent of 10 per cent. of its length, after which it remained unchanged under the tension imposed. The total weight is 8 tons 8 cwt., and the cost was £2. 8s. per cwt. It is guided by 474 grooved pulleys, 14 inches diameter, and by 6 sheaves 5 feet diameter. A new rope will last well for three years, after which it is renewed by splicing in a short portion each time, so as to reduce the amount of stretching.

Inclined plane.

The length of the inclined plane is 2370 yards, at varying gradients; giving an aggregate rise of 77 feet 1 inch, and a mean rise of 1 in 92. The tunnel is 2220 yards long. The average weight of the trains drawn up is 55 tons—and the time occupied is six minutes. The pressure of steam is usually from 50 lbs. to 60 lbs. when the engines begin to wind, and sinks gradually to about 30 lbs. in the reservoir during the time it is working.

Power required to draw carriages up the inclined plane.

From some experiments made by Mr. Edward Woods, the details of which are given, it has been ascertained that each pound per square inch pressure of steam upon the pistons over and above the 7·56 lbs. necessary to overcome the friction of the machinery, is capable of drawing one carriage weighing 5 tons gross up the inclined plane.

Boiler and steam pipes.

On the first erection of these engines, in order to comply with the provisions of an act of parliament, it was necessary to work them with steam generated in boilers, at a distance of 448 yards, and conveyed through pipes 10 inches diameter, laid in a tunnel excavated through the rock. Several experiments were made to determine the relative amounts of pressure in the boiler and the steam reservoir, and the quantity of steam which was condensed in a certain time. The results were, that when the engine was standing still, the difference of pressure was about 3 lbs., and when working with a load it was as much as 13 lbs. The quantity of steam condensed was on an average about 156 gallons per hour.

New boilers.

Subsequently, a set of tubular boilers, similar to those of locomotive engines, were erected close to the engines, and are now constantly worked instead of those at the great distance; the economy of fuel has been considerable. The consumption of gas coke under the tubular boilers is about 15 tons per week, at ten shillings per ton. The larger boilers consumed about 30 tons in the same time.

Mr. Edward Woods gives his approval of the action of the engines, and of the employment of non-condensing engines generally for this class of work, on account of their great simplicity, and the readiness with which they may be brought into full action, so that the greatest power is always at hand to start the train; whilst during the intervals of working the steam may be suffered to accumulate. These advantages are rarely attainable with condensing engines, as unless a small engine be employed to keep up the vacuum, there is a difficulty in starting them with the train attached to the rope.

This communication is accompanied by four detailed drawings of the engines and machinery, and by a model of Mr. Grantham's apparatus for regulating the admission of steam to the valves.

Mr. Fairbairn.

Mr. Fairbairn bore testimony to the good quality of the engines and machinery described by Mr. Grantham; their performance had been very satisfactory.

The mode of keeping the rope in tension was an improvement upon the plan which Mr. Fairbairn had previously adopted at the Wapping Tunnel, of the same railway. He would present drawings of that machinery to the Institution.

The loss by condensation in long steam pipes is so considerable, that it has been generally found more economical to transmit power by a line of shafts, than to convey steam to any great distance.

He had recently constructed some Cornish pumping engines of large size, with side levers and reversed connecting rods; they had answered extremely well. Drawings and descriptions of them would be presented to the Institution.

"On the Percussive Action of Steam and other Aeriform Fluids." By Josiah Parkes, M. Inst. C. E.

Percussive action of steam.

In a previous communication "On the Action of Steam in Cornish single-pumping Engines,"* Mr. Parkes, after a careful analysis of the ascertained facts of the quantity of water which, in the shape of steam, passed through the cylinders of the engines, arrived at the conclusion that the steam's elastic force was insufficient to overcome the resistance opposed to it. On obtaining this remarkable result, he was induced to examine the circumstances under which the steam is applied, and was convinced that from the instantaneous and free communication made between the boiler and the cylinder of these engines, an action, distinct in character from the simple pressure of the steam, must be transmitted to the piston. And, in order to convey some precise idea of the peculiar nature of this action, he adopted the term "percussion," to distinguish such action from that due to the simple elastic force of the steam. Various phenomena, connected with the working of the engine, were adduced in confirmation of the views then advanced. In the present communication Mr. Parkes has resumed the subject, and brought forward numerous facts derived from experiment and observation, on steam and elastic fluids generally, in farther corroboration of his opinions respecting the percussive action of steam in engines.

Experiments with indicator.

The effect of the percussive action of steam may be clearly traced on the indicator diagrams (a series of which, forty-one in number, taken from four engines, with different indicators, the pressure of the steam varying from 6·5 to 34·7 lbs. per square inch, accompanied the communication), and it will be seen that, in every instance, the piston was driven to a greater height than that due to the simple elastic force of the steam; in many instances a greater pressure was marked than existed in the boiler. The difference in the action, according as the steam is admitted suddenly, or gradually, into the cylinder of the engine, may be also distinctly traced on the diagrams.

Experiments with the mercurial column.

The same effects were observed on the sudden admission of steam upon the surface of mercury in the cistern of a mercurial column. In these experiments, the steam being let on gradually, the gauge marked a pressure of 40 lbs. per square inch, which was the true pressure in the boiler; but, being admitted suddenly, the gauge exhibited a pressure of at least 60 lbs., and the same results were repeatedly obtained.

Mr. Perkins's steam generator.

The steam generator of Mr. Perkins will afford a good illustration of the effect of the steam's instantaneous action. The pressure in this apparatus is denoted by an instrument having an index moving round a dial plate. Steam of 26 atmospheres being suddenly admitted, the index was observed, during repeated trials, to register a pressure as high as 36 atmospheres, and then to recede until it remained stationary at 26 atmospheres, which was the pressure in the generator.

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* See *Trans. Institution C. E.*, vol. iii.

The results of these various experiments are arranged in two tables, exhibiting an analysis of the elements into which they may be resolved.

Single pumping and crank engines.

The author then proceeds to point out the different circumstances of the pumping and crank engines, in respect of their realizing, beneficially, the steam's percussive action. In the latter, this instantaneous action takes place (as the indicator diagrams show) when the connecting rod and crank are in one vertical line, so that it is inefficiently expended; the centre, by the agency of the fly wheel, not having been passed. In the former, the load and frictional resistance alone oppose the descent of the piston; the piston is free to move, and the steam's action is wholly efficient in impelling it; and, whatever the amount of the percussive action, it will be accounted for in the effect.

Springing of cylinder covers.

A remarkable confirmation of the conclusions arrived at, and the views advanced by Mr. Parkes in his previous communication, had been furnished by Mr. W. West. The cylinder cover of the Fowey Consols engine, 80 inches in diameter, and weighing 4 tons, springs upwards at the centre $\frac{5}{32}^{\text{nds}}$ of an inch, on the sudden admission of steam, which in the boiler has a pressure of 49·7 lbs; and $\frac{8}{32}^{\text{nds}}$ or $\frac{1}{4}^{\text{th}}$ of an inch, the steam in the boiler being 61·7 lbs.; but no change of form, or springing, occurs when the steam is let on gradually, and fills the cylinder at the same pressure as that in the boiler.

The author adduces many other facts in illustration and confirmation of his views; as, the oscillation of the mercury in steam and vacuum gauges; the audible sounds produced in a steam pipe on suddenly checking the motion of the elastic fluid by shutting a cock; the curious phenomena connected with the impact of elastic fluids on each other, particularly those observed by Mr. Greener on firing gunpowder in long open-ended barrels; and, in conclusion, suggests whether these remarkable facts may not serve to assist in elucidating some of the very difficult and apparently inexplicable phenomena, connected with the explosion of steam boilers.

Mr. Lowe.

Mr. Lowe had recently made some experiments, which in his opinion confirmed Mr. Parkes's views on this interesting subject.

Vibrations of gas pressure gauges.

A pressure gauge, attached to a line of gas pipes, showed, when the communication was slowly opened, a pressure of four inches column of water; but it invariably exhibited a maximum of oscillation of full six inches column on the sudden opening of the small stop cock between the pipe and the gauge.

In a line of pipes, full of gas, the whole volume of gas received an impulse on suddenly opening the valve at one end, and the passage of the undulating wave was indicated by the sudden and successive depression of the water in the gauges along the whole line.

Mr. Homersham.

Mr. Homersham could not agree with Mr. Parkes as to the effect due to what he termed the "percussive action of steam:" he believed that the superior economy of the Cornish Engines, as far as related to the action of steam in the cylinders, would be found to be due to the amount of the expansion of the steam; which depended, not only upon the opening and closing of the steam valve, but also upon the greater or less area of the aperture of the throttle valve. It was evident, that on closing the steam valve, the space between it and the throttle valve would be filled with steam of a density nearly, or quite, equal to that in the boiler; therefore, on the first admission of the steam into the cylinder, it might be presumed to act upon the piston with that pressure: considering, likewise, that a short interval of time necessarily occurs for setting in motion the beam, with the heavy pump rods appended to it; but immediately the piston starts, expansion takes place, as the throttle valve prevents the steam from following the piston freely, so that a greater degree of expansion must take place when the steam is at a higher density; for the throttle valve being then more closed, offers a greater resistance to the steam following the piston. The indicator diagram of the East Crinnis Engine showed this effect to a certain extent, although neither in that nor in the diagram of the Huel Towan Engine was there nearly the same degree of pressure exhibited in the cylinder at the commencement of the stroke, as in the boiler; but it was evident that those diagrams could not be relied upon, as they did not account for the whole duty done by the engines, either on the percussive or the expansive principle.

Assuming a bushel of coal to weigh 94 lbs., as generally reckoned in Cornwall, and that 1 lb. of coal would evaporate 10½ lbs. of water, it could readily be shown, that the quantity of water converted into steam by one bushel of coal, would, when expanded in a cylinder, during $\frac{18}{20}$ths of the stroke, lift upwards of 257 million lbs. one foot high in one minute; which was a much greater duty than was realised by any Cornish engine.

Mr. S. Seaward.

Mr. Seaward allowed that Mr. Parkes had clearly shown, that a certain amount of effect was due to the sudden impact of the steam upon the piston of a pumping engine. Whether the term "percussion," as applied to this action, was the proper one, he would not then examine; but the effects shown to have been produced, and the phenomena attendant upon the exhibition, were so remarkable, that he conceived the subject to merit the most deliberate investigation of engineers as well as philosophers. He had previously objected to the theory, on the ground that the effect could only be in the ratio of the weight of the steam multiplied into its velocity; but he believed the subject must be examined in a different manner; and although the principle must always have existed, it was only in consequence of modifications in the application of steam, that the effects had been so fully developed.

Mr. Parkes.

Mr. Parkes mentioned, that since his paper had been written, he had found an experiment which was strictly analogous to his proposition. It was related by Mr. Robins, who was so justly celebrated as a mathematician and philosopher, and first discovered that the gas evolved from gunpowder was a permanently elastic fluid.

"When gunpowder is fired in an exhausted receiver, the mercurial gauge instantly descends upon the explosion, and as suddenly ascends again. After a few vibrations, none of which, except the first, are of any great extent, it fixes at a point which indicates the density of the inclosed gas."

He considered this result as corroborating those obtained by himself, as well as justifying the comparison he had drawn between the instantaneous action of gunpowder gas and steam. Mr. Robins's words precisely described the steam's action, as traced on the indicator diagram exhibited.

The springing of the cylinder cover referred to, and in the manner stated, must, he thought, satisfy every one, that the steam's instantaneous action far exceeded in effect that of its simple elastic force, which was proved to have been unequal to produce any change in the parallelism of the cover.

Expansion of steam.

As regarded Mr. Homersham's investigation of the power of the steam in the Huel Towan Engine, it was correct that the initial steam was in a state of expansion during $\frac{19}{20}$ths of the stroke, but not all the steam, for it had not all entered the cylinder until the piston had travelled through nearly $\frac{5}{20}$ths of the stroke. His calculations were, therefore, hypothetical, and not in accordance with the facts of Mr. Henwood's experiment.

June 8, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: John Ball and Adalbert Morawski (of the Grand Duchy of Posen), as Associates.

"Description of Stephenson's Theatre Machinery."—By J. B. Birch, Grad. Inst. C. E.

Theatre machinery.

In this communication the author describes a system of machinery which was erected for the purpose of avoiding the confusion, mistakes, and noise, consequent upon the number of men usually employed in the stage department of a theatre, and with a reduced number of men to effect more perfectly all the operations required there.

The apparatus provides means for shifting simultaneously and without noise, any number of distinct pieces of scenery, bringing at the same time into view other scenes to replace them. The general arrangement of the machinery for effecting this, is fully described.

The interior of the house between the basement and the roof, is divided into four compartments, viz.:

Under the stage.

1. A raised platform on which the gearing for working the stage traps is placed. The trap frames are mounted upon rollers; they traverse on the lower platform in every direction; and when brought under the apertures in the stage, allow the traps to sink or rise steadily at any required speed.

Stage level.

2. The stage, with its traps of various dimensions, including a considerable portion formed to rise or fall by suitable machinery, and called the sinking stage.

First story above stage.

3. The lower flies or corridor, between which and the stage are placed the wings or side scenes, and the border frames are suspended.

Second story above stage.

4. The upper flies, upon which is placed the machinery to communicate motion to the whole, from the upper horizontal shaft, by means of bevel gear, provided with double clutches to reverse the motion and shafts, on the lower ends of which are the slow-motion wheels and drums, an endless chain is driven horizontally in either direction; to this are attached the borders representing clouds, foliage, arches, &c.

The side scenes or wing frames, the number of which is determined by the depth of the stage. may be either flat, circular, or triangular, and receive a rotary motion, combined with or apart from a forward and backward movement at pleasure, and can be placed at any desired angle to the audience. At every change of the scene they revolve through 120° or $\frac{1}{3}$rd of a circle, and the scenes when removed from sight are replaced by those which are to succeed them.

The traversing frames revolve on a centre, and are suspended from the border frames, or from the upper part of the theatre, for crossing the stage in any direction, and at any given inclination.

Several improvements in the mode of lighting the stage and house have been introduced with the machinery; they are more fully referred to in the detailed description which accompanies the ten elaborate drawings sent with this communication.

"On the Combustion of Anthracite, and its value as a Fuel for Steam Engine and other Furnaces." By Andrew Fyfe, M.D.

Combustion of anthracite.

Anthracite, although known as a valuable fuel for particular purposes, is so difficult of combustion, that it has hitherto been very partially brought into use; it has, however, become desirable to introduce it more generally, and the author having been engaged in testing the value of Mr. Bell's patent furnace, was induced to make some experiments on the use of anthracite in conjunction with that system.

Bell's patent furnace.

The objects sought to be obtained by the apparatus are, to insure a larger amount of evaporation, by passing heated air, unmixed with the products of combustion, through tubes in the boiler and surrounded by the water, thus increasing the evaporating surface; and that the surplus caloric taken originally from the fuel, and not given out in its passage through the water, should be beneficially used in aiding the combustion beneath the boiler.

Heated air

It has been found in the manufacture of iron that anthracite could be advantageously used by means of heated air; the author therefore considered that the experiments upon this apparatus (the intrinsic merits of which he does not at all discuss in this communication), afforded an advantageous opportunity for ascertaining in what manner this fuel could be successfully employed under steam boilers.

Conditions of the experiments.

The anthracite supplied to the author was unfortunately of inferior quality, analysis giving only of fixed carbon 71·4, and of volatile inflammable matter 13·3; the setting of the boiler required much alteration before sufficient draught could be procured. The fuel was thrown on to the bars by hand, which is the worst manner of using it, as from its density, and its being a bad conductor of heat, it decrepitates when it first inflames, unless it is previously warmed —this was found to occur for a short time, but on the application of the heated air the decrepitation ceased, and combustion went on steadily.

In ascertaining the amount of evaporation, the water at a temperature of 45° was injected by hand from a vessel, the content of which was measured, and the level in the boiler regulated by the float and index.

The fire was brought up to a certain intensity before commencing, and was left in the same state at the end of the experiment; this mode of proceeding, although objectionable with bituminous coal, is not so with anthracite, as it does not swell during combustion so as to alter the bulk of the fire.

Results of the experiment.

The results of an experiment extending over 8½ hours without interruption, are then shown in a tabular form. In this trial, 448 lbs. of anthracite were thrown on the fire in four equal portions, at intervals of two hours; 3560 lbs. of water at 45° were pumped into the boiler and evaporated under a pressure of 17 lbs. per square inch.

Evaporation.

After deducting 40½ lbs. of unconsumed coal which fell through the bars, the amount of evaporation was found to be 8·73 lbs. of water for each pound of coal consumed. If the feed water had been at a temperature of 212° the evaporation would have amounted to 10·03 lbs.

During this trial the air in the tubes of the boiler never exceeded 430°, but on subsequent occasions it was raised as high as 700°.

This product of evaporation is below that obtained by other persons, which the author attributes to the inferior quality of the specimens of anthracite, and the admission of cold air above the furnace bars when throwing on the fuel.

Efficiency of the fuel.

His opinion is, that when anthracite is completely burned, the practical evaporative power will be found directly in proportion to the amount of fixed carbon contained by it—that with the exception of the loss of heat which is always transmitted to the brick-work of the furnace, and of that which is carried up the chimney to keep up the draught, the whole of that evolved by the fixed carbon will be retained by the water; because from good fuel there is little or no escape of gaseous matter, and hence the superior efficacy of anthracite.

Analysis.

From the analysis of a number of specimens of anthracite, the author found the quantity of fixed carbon to amount to 90 per cent.

The evaporative power of these fuels, as fixed by Berthier's process (la voie sèche), would amount to 12·3 lbs. of water for each pound of coal consumed.

Evaporative power of the fuel.

He calculates that 6 lbs. of anthracite will evaporate 1 cubic foot of water under the ordinary circumstances of a steam engine boiler, and taking the average specific gravity of bituminous fuel at 1280, while that of anthracite is 1410, there is a difference of nearly 10 per cent. in favour of the latter, considering the space in which it can be stowed.

Rate of combustion.

This is an important consideration for its use on board steam vessels, but it is essential that its rate of combustion should be such as to raise steam rapidly, its capabilities for which the author then proceeds to examine, and deduces from the experiments that the combustion of the anthracite was carried on so as to produce a greater amount of evaporation, in a given time, than could be obtained from bituminous coal. This result is attributed in some degree to the use of heated air.

The author recommends that the anthracite should be supplied to the furnace by a hopper through the boiler,* wherein it is warmed before reaching the fire bars, which obviates the inconvenience of decrepitation, and insures regularity in the supply of steam.

Mr. Lowe.

Mr. Lowe saw no reason to doubt the results recorded by so accurate an experimenter as Dr. Fyfe, which proved that anthracite was efficient just in the proportion of the carbon it contained, but he was at a loss to reconcile this with the opinion of Mr. C. W. Williams, who recommended the addition of bituminous substances to pure carbon, as a means of increasing the calorific power of fuel. He must repeat the opinion expressed by him on a former occasion, that the coal most free from elementary oxygen, would in practice be found the most effective fuel. Neither could any fuel be used too dry or too hot. At the gas works under his charge, a considerable economy had been effected by Mr. Croll's patent process of using the coke as it was drawn from the retorts, and thrown in an incandescent state into the furnaces.

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* *Player's Patent.*

June 15, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected:—Daniel Pinkney Hewett and John Boustead as Graduates; and Gerrit Simons (of the Hague) as an Associate.

"Description of the new Sewer in the Valley of the Cowgate, Edinburgh." By George Smith.

Sewers in Edinburgh

In this communication the author first gives an account of a complete system of drainage, designed by him as architect to the Commissioners for improving the City of Edinburgh, and then describes the mode of constructing the first sewer, which begins at the south back of the Canongate, passes along the Cowgate, and through the Grass-market to the foot of the Bow.

This principal sewer is 950 feet long; it was built in several sections; the upper portion was 4 feet high by 2 feet 6 inches wide, and increased at the lower extremity to 5 feet high by 3 feet wide; it was constructed of stone with vertical sides, and large flat stones for both the sills and the covers—the dimensions of the branch drains varied in proportion to the quantity of matter passing through them; they were situated opposite the cross streets, and had a cesspool to each, with a malleable iron grating hinged to afford access for cleansing them.

The average depth of the excavations was 9 feet; a great portion of the work demanded great precaution in executing, on account of the narrowness of the streets, the frequent floods, the local impediments from the gas pipes, &c., and the soft character of the ground, as in some places the foundation stones sunk deep into the mossy soil by their own weight; it has, however, proved very successful, and will doubtless induce an extension of the sewage of the City of Edinburgh, which has been too long neglected.

The paper was accompanied by two drawings of the construction of the sewers, and the plan of the general system proposed, with the report to the Commissioners and other explanatory documents.

"On an uniform system of Screw Threads." By Joseph Whitworth, Assoc. Inst. C. E.

Uniform screw threads.

The subject considered in this paper, is the importance of having a constant thread for a given diameter in all screws used in fitting up steam engines and other machinery. It is argued, that uniformity of thread would be productive of economy, both in the use of screwing apparatus, and in the consumption of bolts and nuts. The refitting shop of a railway or steam packet company affords a striking instance of the advantage to be derived from the application of this principle. If the same system of screw threads were common to the different engines, a single set of screwing tackle would suffice for any repairs.

A common standard.

No attempt appears to have been hitherto made to attain this important object. Engineers have adopted their threads without reference to a common standard. Any such standard must be in a great measure arbitrary, and hence its absence may be accounted for.

Choice of thread.

Characters and conditions.

The author enters at some length into the consideration of the circumstances affecting the choice of a thread, with a view to show that it cannot be determined by precise rules. The essential characters of the screw thread are—pitch, depth, and form. The required conditions are—power, strength, and durability. But the exact degree or proportion in which these conditions are required, cannot be ascertained, and consequently the characters on which they depend cannot be fixed by calculation. An approximation may be made, but within a certain limit the decision is arbitrary.

The mutual dependance of the several conditions, and the relation subsisting between the constituent characters, are noticed as having a tendency to perplex in the choice of a thread.

Want of uniformity.

From the vagueness of the principles involved in the subject, a corresponding latitude was naturally to be expected in the practical application of them, and accordingly, instead of that uniformity which is so desirable, there prevails a diversity so great as almost to discourage any hope of its removal. The only mode in which this could be effected, would be by a compromise; all parties consenting to adopt a medium for the sake of common advantage. The average pitch and depth of the various threads used by the leading engineers, would thus become the common standard, which would not only have the advantage of conciliating general concurrence, but would in all probability approach very nearly to the true standard for practical purposes.

Selection of a standard.

The author then proceeds to describe the mode adopted by Messrs. Whitworth and Co., some years since, in selecting their threads upon this principle. An extensive collection was made of screw-bolts from the principal workshops throughout England, and the average thread was carefully observed for different diameters. The ¼ inch, ½ inch, and 1½ inch, were particularly selected, and taken as the fixed points of a scale by which the intermediate sizes were regulated, avoiding small fractional parts in the number of threads to the inch. The scale was afterwards extended to 6 inches. The pitches thus obtained for angular threads were the following:—

Diameter in inches	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1"	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2"
No. of threads to the inch	20	18	16	14	12	11	10	9	8	7	7	6	6	5	5	$4\frac{1}{2}$	$4\frac{1}{2}$
Diameter in inches	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3"	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4"	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5"	$5\frac{1}{4}$	5 .	$5\frac{3}{4}$	6"	
No. of threads to the inch	4	4	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{1}{4}$	3	3	$2\frac{7}{8}$	$2\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	

Above the diameter of 1 inch the same pitch is used for two sizes, to avoid small fractional parts. The proportion between the pitch and the diameter varies throughout the entire scale.

Pitch of thread.

Thus the pitch of the $\frac{1}{4}$ inch screw is $\frac{1}{5}$th of the diameter; that of the $\frac{1}{2}$ inch $\frac{1}{6}$th, of the 1 inch $\frac{1}{8}$th, of the 4 inches $\frac{1}{12}$th, and of the 6 inches $\frac{1}{15}$th.

The depth of the thread in the various specimens is then alluded to. In this respect the variation was greater than in the pitch. The angle made by the sides of the thread being taken as an expression for the depth, the mean of the angle in 1 inch screws was found to be about 55°, which was also nearly the mean in screws of different diameters. Hence it was adopted throughout the scale, and a constant proportion was thus established between the depth and the pitch of the thread. In calculating the former a deduction must be made for the quantity rounded off, amounting to $\frac{1}{3}$rd of the whole depth, *i. e.* $\frac{1}{6}$th from the top, and $\frac{1}{6}$th from the bottom of the thread. Making this deduction, the angle of 55° gives for the actual depth rather more than $\frac{3}{5}$ths, and less than $\frac{2}{3}$rds of the pitch.

Depth of thread.

Calculating the depth.

It is observed, that the system of threads thus selected has already been widely extended, demonstrating the practicability and advantage of the proposed plan. The author then notices the obstacles to general uniformity arising from the inconvenience which any change would occasion, in existing establishments, and also from the imperfect screwing tackle in general use. He anticipates as an important result of a combined effort to introduce uniformity, that screwing tackle generally would be much improved, and the efficiency and economy of bolts and nuts be thereby increased.

He recommends also standard gauges of the diameters and threads, as they would form a convenient adjunct to the screwing apparatus, and would be applicable to other useful purposes.

Mr. Field.

Mr. Field claimed for the late Mr. Maudslay the credit of the first attempt to introduce uniformity of thread—it was well known how incessantly his attention and skill had been devoted to this object, and with what success his efforts had been attended. He would at the same time accord great merit to Mr. Whitworth, not only for his present effort to introduce a very desirable measure, but also for the general excellency of the screwing tackle made under his directions.

Mr. S. Seaward.

Mr. Seaward corroborated all that Mr. Field had advanced: he had always considered that to Mr. Maudslay the mechanical world was indebted for the accuracy with which screws were now made. He considered the plan proposed by Mr. Whitworth to be good, but difficult of attainment in old-established manufactories, where very extensive assortments of screwing tackle already existed.

The President.

The President concurred in the opinion, that it was to Mr. Maudslay's well-known talent and skill that the mechanical world was indebted for the great improvements in the form of the screw, and the mode of its manufacture; but it was to Mr. Whitworth that the Institution was indebted for having brought the subject before the meeting: he trusted that this example would not be lost upon the numerous members, who could contribute so largely to the interests of the meetings, by recording the facts which came under their notice in the course of their diurnal employments.

"Account of the original construction and present state of the Plymouth Breakwater." By William Stuart, M. Inst. C. E.

Plymouth Breakwater.

In the year 1806, the Lords Commissioners of the Admiralty instructed the late Mr. John Rennie, C. E., and Mr. Whidby, then Master-Attendant at Woolwich Dock Yard, to make a survey of Plymouth Sound, with a view to the construction of a breakwater for sheltering vessels.

Their report was favourably received, but it was not until 1812 that the works were commenced.

Design of Rennie and Whidby.

Their plan consisted of a pier or breakwater 1700 yards in length, the centre part of which, 1000 yards long, was straight, with an extension at each end 250 yards in length, placed at an angle of 20° with the main body. The top to be 30 feet wide at the level of 10 feet above the low water of an ordinary spring tide:—the slope towards the sea to be 3 feet horizontal to 1 foot perpendicular, and on the land-side 1 foot 6 inches horizontal to 1 foot perpendicular.

Progress of the work.

By the middle of March, 1813, the work had been brought up in parts to within 5 feet of low-water mark of spring tides—at this period 43,789 tons of stone had been deposited—and in the month of March of the following year sufficient shelter was afforded for ships of war to anchor in the Sound instead of in Cawsand Bay.

It was then determined to raise the whole structure to the height of 20 feet above low-water spring tides: great exertions were made to complete it rapidly, and during the week ending on the 24th of May, 1816, the quantity of stone deposited amounted to 15,329 tons, which was the largest quantity ever conveyed within the same space of time.

Storms in 1817.

Slight injury had frequently been received by the works whilst in progress, but the storm of the night of the 19th of January, 1817, was the first which materially affected them. The most destructive effects were, however, produced by the storm of the 22d and 23d of November, 1824. On that occasion the spring-tide rose 7 feet higher than usual; and so great was its power, that a length of 796 yards of finished work was completely overturned, and the remaining parts slightly injured.

In 1824.

Slopes increased.

It was observed, that the effects of this storm left the slope from low-water mark upward at about 5 feet horizontal to 1 foot vertical. It was therefore determined to adopt that angle of inclination for the exterior or sea-side, and a slope of 2 to 1 for the inside. The centre line of the breakwater was also removed 39 feet 6 inches towards the north, and the top width was increased to 45 feet.

The works continued upon this scale until 1830, when a fore-shore was added of a width of 50 feet at the toe of the south slope at the west end, and of 30 feet at the east end of the main arm: for this purpose 600,000 tons of stone were deposited.

The extreme western end of the breakwater was then, after more alterations and extensions, terminated by a circular head, with an inverted arch as a foundation for a light-house, now constructing under the direction of Messrs. Walker and Burges.

Light-house.

In consequence of further injuries from storms in 1838, when

Storms in 1838.

large quantities of stones of 15 or 20 tons' weight each were torn from below low water, and carried completely over the top of the Breakwater, a further extension of the fore-shore was made, and a projecting buttress built to secure the foot of the south slope, to afford additional security to the light-house, and to prevent the stones from the fore-shore being carried over to the north side.

Quantity of stone used.

From the time of its commencement in August, 1812, until the 31st of March, 1841, there had been deposited upon this work 3,369,261 tons of stone.

Cost.

The expenditure upon the whole work, when completed, will, it is estimated, be within one million and a half sterling.

The main body of the work is composed of blocks of limestone from the quarries of Oreston, adjoining the harbour of Catwater. They were deposited from vessels constructed for the purpose. In certain portions of the work the blocks have been subsequently ranged from a diving bell. The buttress and the works now in progress round the west end are composed of granite masonry, dovetailed horizontally, and fixed vertically by iron levis cramps.

Subsequently to the reception of the plan of Messrs. Rennie and Whidby, most of the leading engineers of the day were consulted, under whose directions the author has superintended the execution of the work.

The communication is accompanied by six elaborate drawings by Mr. Dobson, illustrating in detail the various stages of the work, and the mode of construction.

Mr. Rendel.

Mr. Rendel could have wished that the account of this interesting work, the most extensive of the kind in Great Britain, had entered more fully into details, not only of the difficulties met with and overcome, but of the peculiarities of the construction: there were many points connected with it of great importance to engineers. He would allude to one only upon which no information was given: the amount of interstice in the whole cubic content as compared with the mass of materials employed; an accurate account had been kept of the quantity of stone deposited, and knowing the cube of the mass at a given period, he had ascertained the amount of interstice or vacant space in the old part of the works to be at one time 37 per cent. This great deficiency of solidity had arisen from the employment of an excess of large stone, or rather from a deficiency of small stone to fill the interstices between the large stones.

June 22, 1841.

The PRESIDENT in the Chair.

The following were balloted for and elected: Joseph Colthurst, as a Graduate; Colonel George Ritso Jervis, B. E., Captain Henry Goodwyn, B. E., and William Lamb Arrowsmith, as Associates.

"On the Construction and Use of Geological Models in connexion with Civil Engineering." By Thomas Sopwith, F. G. S., M. Inst. C. E.

Geological models.

The author commences this paper with a review of the various methods adopted for the representation of objects required in carrying out the designs of engineers, architects, and mechanics—whether as the means whereby such designs are first studied, and afterwards matured—as guides for the resident superintendents and workmen—or for being preserved as records of what has been executed, and studies for those who may be engaged in similar undertakings.

He then proceeds to elucidate the advantages peculiarly possessed by models for demonstrating practical results in Geology and Mining, dividing the subject into six heads, as follows:

1. On the application of modelling to geological and mining purposes.
2. On the materials to be employed.
3. On the mode of construction.
4. On the scales to be employed.
5. On the objects to be represented.
6. On the use of geological models, and the connexion of the subject with civil engineering.

Application of modelling to geology and mining.

1. A large number of plans and sections is usually required to elucidate with clearness the geology of a district, and the nature and extent of mining operations; and few departments of practical science admit of greater improvement than the art of delineating mining plans in connexion with geological features.

Much ingenuity has been exercised in representing the undulating surface of countries either by the process called "relief-engraving," (procèdé Collas), or as in the Ordnance Maps of England and Wales, and Mr. Greenough's recent edition of his Geological Map; but even in comparison with these a model affords a more correct idea. Hence models in relief are more peculiarly applicable in all cases where it is desirable to comprehend at once the relations of the several parts, and it is evidently still better adapted to explain the geological conditions; especially when it is required to show the relative position of various rocks, their inclination, thickness, extent, and the disturbances to which they have been subjected, which could only be understood by comparing together a number of drawings.

To those interested in mining, therefore, the easiest mode of conveying ideas is by modelling. This was illustrated by two models of the Forest of Dean, and by reference to Mr. Jordan's model of the Dolcoath mine, now in the Museum of Economic Geology.

Materials for models.

2. The first material for forming a model which naturally occurs to the mind is clay, pins and wires being used to define the principal elevations. Plaster of Paris has occasionally been used, and is well adapted for solid forms, where the edges are not exposed to injury; but its brittleness and contraction in drying are objectionable. Papier Maché is a more elegant and durable material, but the expense of the requisite moulds prevents its general use. Coloured wax is adapted for small models not subject to be handled. Pottery appears to possess more requisites, but many corresponding disadvantages. Of all the materials which the author has employed, he found none so generally useful as well-seasoned wood, whether for the facility with which the requisite forms are attained, for durability, for portraying different strata by various-coloured woods, or for comparative economy.

Mode of construction.

3. The mode of constructing geological models had been briefly alluded to by the author on a preceding occasion.* It is more fully described in the present communication, and was illustrated by complete models, and the detached parts for forming them purposely made on a large scale.

The plan of the district being divided by lines at given distances apart, into a certain number of squares, a series of thin slips of wood are made to intersect each other, corresponding to the lines so drawn —upon these slips the profile of the surface and the positions of the strata are delineated, when it is intended that the model when complete shall be dissected; the compartments are then filled in with wood, and carved down to the lines upon the slips; the several strata thus rest upon the subordinate beds, and can be detached in a mass or in compartments; these being geologically coloured, convey an accurate idea of the relative positions of the strata, and display with the utmost clearness the mining operations in each. This system is applicable to any extent: and the operation of forming the model is so simple, that a skilful workman at once comprehends and executes unerringly the instructions given him by the engineer or surveyor, as the accuracy entirely depends upon the profile which is drawn upon the slips. The author considers lime-tree or plane to be the most suitable wood for the purpose; but in the construction of small models for showing peculiar geological features or disturbances of strata, he uses various coloured woods: as an illustration of which he showed a series of twelve models, which (with a printed description*) are now in the Museum of the Institution. These contain 579 pieces of wood, one of them consisting of 130 pieces. By fitting the parallel layers of wood together, and arranging them in conformity with sections of strata of the carboniferous limestones and coal measures of the north of England, he illustrates the formation of that district, and the nature of its dislocations, &c. better than can be done by any number of plans and sections.

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* *Minutes of Proceedings*, Inst. C. E. 1840, p. 49.

Scales to be employed.

4. Attention is drawn at some length to the proportion to be observed between the horizontal and vertical scales, and the relative merits of corresponding and dissimilar horizontal and vertical scales fully examined, illustrating the positions by two models of the Forest of Dean, in one of which the vertical is enlarged to three times that of the horizontal scale; while the other has the scales exactly alike. For the conventional purpose of giving an idea of a country such as would be formed by a general observer passing through it, the former model appeared best adapted; but in a scientific point of view the latter had a decided advantage, being based on geometrical truth, and conveying an exact knowledge of the real, but not of the apparent relations of the surfaces, and other objects represented.

Objects to be represented.

5. Models had hitherto been chiefly used for conveying impressions of tracts of the surfaces of countries, or for displaying the minute tracery and proportions of buildings. The author's views have been more especially directed to introducing the construction of models for geological and mining purposes, for which he considers them peculiarly adapted.

The series of models now presented to the Institution, contains examples of various geological phenomena of regular stratification—interruption by slips, faults, and dykes—the effects of denudations in exposing to view the various strata—the deceptive appearance of the course of mineral veins on the surface—the intersection of veins

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* Description of a series of Geological Models, &c. By Thos. Sopwith, F.G.S., &c. 12mo. Newcastle, 1841.

—and many other details which are intimately connected with practical mining.

Models used in civil engineering.

6. The author then proceeds to describe his view of the uses of such models, and the connexion of the subject with civil engineering.

He considers that by them a practical knowledge of geology may be attained by the civil engineer, and that such knowledge is indispensable for his guidance in many of the works he is called upon to undertake in the exercise of his profession. It is to an engineer that the merit is justly due of having, by efficiently labouring to establish English geology on a firm basis, acquired the title of "Father of Geology," which has been generally conceded to the late Mr. William Smith.

The avocations of the civil engineer peculiarly qualify him for an observant geologist; and being called upon to visit so many different districts, the remarks he might make would be replete with instruction. These observations might be illustrated more efficiently by models than by any other means; at the same time they might be made to answer another purpose—that of demonstrating to the owners of mineral property the advantage or the futility of commencing researches or mining speculations.

Plans do not admit of such certainty of definition as modelling, and no regular system of planning mining districts has yet been generally practised, by which the engineer can judge of the probable results of the operations which he is often called upon to direct. As a record of mining operations, models of this kind are pre-eminently valuable; the exact position not only of the mineral veins and the strata are clearly shown, but the quantities extracted are registered, and a guide for future proceedings is established. The author contends that it is a duty to secure, while it is in our power, such records of mining operations as may enable us and our successors really to exhaust whatever minerals can be worked with advantage.

Dr. Buckland.

Moulds for plaster casts.

As being in some degree connected with the subject under discussion, Dr. Buckland described a mode used by Sir John Robison, for obtaining moulds for plaster casts. The object, of which the mould was required, was immersed in a mixture of common glue, dissolved in brewers' sweet wort of about the consistency of thick cream, and allowed to remain until the mass became stiff; it was then released by cutting the mould open, when it would be found to resume its original form like Indian rubber: holes were made in it for pouring in the plaster of Paris, and for carrying off the air; from such moulds, casts of the most delicate objects could be taken.

He entirely concurred in the praise of the beauty and the utility of the models which had been described, and he hailed with much pleasure the co-operation of engineers in the study of geology; by their researches in the science of dynamics, and their knowledge of the power of elastic vapours, light might be thrown upon the upheavings of the great mountain ranges; whether that had been the work of time, or by the sudden development of a mighty force, it was peculiarly the province of the civil engineer and the mathematician to consider and to explain. The observation of the effects of torrents, the causes of removal of masses of material, the disturbance of strata in certain localities, and numerous other instances of the utmost interest to the geologist, were even more important to engineers.

Mining models.

In mining operations, where for want of accurate records of previous workings, much expense was frequently incurred, accompanied with loss of human life, the adoption of the models proposed by Mr. Sopwith was of the utmost importance; he trusted that the keeping of such records of present operations would be rendered compulsory by legislative enactment, that proprietors of collieries would not be permitted by inattention to do irremediable injury to the mineral and coal basins, which were the vital riches of the country. If accurate models of all the coal districts were prepared, similar to that of the Forest of Dean, a close estimate of the duration of the supply of mineral fuel could be made: present expense would also be avoided, by the best positions for sinking pits and erecting engines for draining being fixed upon with greater certainty, the positions and extent of the beds or veins of coal or minerals, the faults, dykes, slips, &c., would be shown for the guidance of speculators; in fact, these models would do much towards giving a degree of precision to a branch of engineering, in which the greatest uncertainty prevailed at present.

Thames Tunnel borings.

As an instance of the utility of a knowledge of geology to the engineer, he might mention, that after the Thames Tunnel had been commenced by Sir Isambard Brunel, upon an assurance from those who made the borings that they had reached the London clay, it was found that they were actually traversing the sands of the plastic clay; hence arose nearly all the difficulties which the engineer had displayed so much skill and perseverance in overcoming.

Artesian well at Paris.

It was the adaptation of the science of geology to engineering, which enabled Monsieur Arago to inspire the contractor for the Artesian Well of the Abattoir de Grenelle, with the confidence that he should eventually obtain the abundant supply of water which had from the commencement been foretold—and which had now been realised.

In short, whether viewed in connexion with the labours of the mining engineer as directing his proceedings with greater certainty, or giving a correct knowledge of the properties of materials employed in the works of the civil engineer, and for numerous other self-evident reasons, he considered the study of geology to be indispensable for every member of the profession.

June 29, 1841.

HENRY ROBINSON PALMER, V. P. in the Chair.

The following were balloted for and elected:—George Briant Wheeler Jackson, as a Graduate; William Crellin Pickersgill, William Millar, Robert Cantwell, Thomas Clark, and Hugh Roland Labatt, as Associates.

"Description of the Bann Reservoirs, County Down, Ireland." By John Frederick Bateman, M. Inst. C. E.

The Bann reservoirs.

The construction of the reservoirs described in this communication was undertaken with the view of regulating the quantity of water in the River Bann, and more effectually supplying water power to the flourishing and increasing establishments on its banks; this river is, from the bare and naked character of the Mourne Mountains, among which it rises, naturally liable to the greatest irregularity in its volume; devastating floods frequently pour down the channel, where a few hours previously there was not sufficient water for agricultural purposes: greatly injurious as this must have been to the agriculturist, it was infinitely more so to the mill-owners, who depended entirely upon water power for their manufactories.

Mr. Fairbairn was consulted on the subject; he examined the locality, and advised the formation of reservoirs: the author was then appointed the engineer, and acting in some degree upon the suggestions of his predecessor, whom he continued to consult, the works were undertaken which are described in the present paper.

Act of parliament.

The peculiarities in the act of parliament, granted in 1836, constituting the proprietors of the mills a Joint Stock Company, for the formation of the Bann reservoirs, are detailed.

The works were originally intended to have been more extensive than have been really executed. The reservoir at Lough Island Reavy, is alone described: the ground in that spot was admirably adapted for the work, being the bottom of a basin, which was bounded on all sides by rugged hills of granite; in the centre of the basin was a small lake, at the bottom of which was discovered a bed several feet in thickness, of fossil confervæ, similar to those discovered by Professor Silliman at Massachusetts, North America. This interesting geological fact was first noticed by Dr. Hunter of Bryansford; the confervæ appeared like an impalpable powder, but when viewed through a powerful microscope, they were found to be regular parallelograms, many of them covered with striæ. They are described by naturalists as the fossil skeletons of minute vegetables.

Fossil confervæ.

Construction.

The situation fixed upon for the reservoir, rendered necessary the construction of four embankments between the hills, so as to raise the water to a height of 35 feet above the summer level of the lake.

Embankments.

These embankments were all constructed in a similar manner, only varying in the slopes and thickness of the stone facing according to the extent and situation.

The whole substratum of the valley was water-tight, either from the existence of the solid rock, dense clay, or of hard, compact, mountain gravel; so that there was no difficulty in securing the foot of the puddle. A trench was sunk into the water-tight stratum, whence the vertical puddle wall was carried up with the bank to the required height. It was 12 feet in width at 40 feet below the top, diminishing gradually to 8 feet wide at the summit, and was worked in regular layers of 8 inches in thickness.

Puddle.

The embankments were formed in concave layers 3 feet thick, each layer being completed before another was commenced, steps being cut in the ground where necessary, to receive the layers.

Peat used.

In order further to secure the tightness of the bank, a lining of peat 15 inches in thickness was brought up on the inside of the puddle, and a layer of the same material was laid upon the face of the slope; it was cut small, placed in thin courses like the puddle, and merely trodden down without more moisture than it naturally contained. The author advocates the use of peat in such positions, as, from its light and fibrous nature, in case of a leak occurring, the draught would attract into it all the fibrous particles, which by degrees would stop the holes sufficiently for the silt to settle over and effectually close the aperture.

Above the peat a course of gravel 3 feet in thickness was laid, and upon that the stone pitching, forming the inner side of the bank.

Slopes.

The inner slopes were for 20 feet below the top of the bank, 2½ horizontal to 1 vertical; the outer were 2 horizontal to 1 vertical; where they were deeper than 20 feet, the remainder of the backs sloped 3 to 1 on the inside, and 2½ to 1 on the outside.

All the embankments are 12 feet wide at the top, and 5 feet above the water level.

Discharge pipes.

The centre of the deepest part of the embankment was traversed by a stone culvert, in which were placed two rows of cast-iron discharge pipes, 18 inches diameter, with suitable valves. A leak was discovered in the centre of the masonry of this culvert, occasioned by the engineer's instructions not being obeyed. The details of the methods employed for remedying this defect are given at length; as also those of the experiments upon cements made by the author after the data given by Vicat. The materials which were most accessible for the work were tested very carefully, and from the results, it was determined to employ mortar composed of rich Manx or mountain lime carefully slaked, and clay burned with peat in the open air. The proportions were 2½ of clay to 1 of lime. They were ground together, and being mixed with as much water as was necessary, the mortar was used immediately. The mortar for the backing had one measure of sand added; the grout had two measures of sand in it, and was used thin.

Cements.

The concrete was composed of one part of lime, two and a half of calcined clay, and about three parts of sharp gravel.

This cement appeared to set hard, and to be perfectly tight; but when the reservoir was partially filled, several leaks were discovered, which rendered an examination necessary, and some energetic measures were taken to stop them, all which are described.

Vicat's cement.

The result of the author's experience seems to be, that mortar made from rich lime and calcined clay, as recommended by Vicat, may set and harden under water when there is little pressure, but that it is not able to resist the pressure of a considerable depth of water.

The details of the construction of the masonry of the valve house, the fore bay, the waste weir, the bridge of three arches, constructed over the feeder from the river Muddock, and the various feeders for supplying the reservoir, are given at length, with the particulars of the expenditure of the sum of £14,891, which was the cost of the work, exclusive of land compensation, or salaries and professional charges.

The particulars are also given of a series of observations with rain gauges continued for two years, for the purpose of furnishing data for computing the extent of reservoir which would be necessary to insure a supply of water throughout the year.

The communication is accompanied by detailed drawings of every part of the works, and a plan of the district in which they are situated.

"Description of a machine for sewing Flat Ropes." By Eugenius Birch, Grad. Inst. C. E.

Machine for sewing flat Ropes.

In a previous communication, Mr. Birch described and gave drawings of the ingenious machinery invented by Captain Huddart: the subject was not entirely complete without the description of the present machine, which, although not of great importance in a scientific point of view, is well worthy of notice, in consequence of its being attached to this valuable rope machinery, and of its having been worked so successfully.

It is used for sewing or lacing together ropes, and forming them into flat bands, which are used for mining purposes, &c.

The bands or flats generally consist of four ropes, which are placed parallel to each other, and paired in contrary directions to the angle of the lay; being held under an equal degree of tension, they are sewn together with two cords or lines, by needles which are driven through holes previously pierced in the ropes, at an angle of 45 degrees, and the cords are then drawn tightly in a lateral direction.

That the ropes may be pierced more easily, it is necessary that the tar which they retain from the process of warm registering, should be softened: this is accomplished by passing them through a steam chest, whence they are drawn into a frame composed of four plates, which are placed so as to compress the ropes while they are in the softened state, and form a die which can be regulated to the size of the ropes required to be sewn. The piercing operation is performed in the die, which has slots in its sides for passing the piercers through.

Strength of flat Ropes.

There are not any recorded experiments on the strength of the ropes, but it is considered, that the amount of strength possessed by the flat rope is not equal to the sum of that of the four ropes before they were united; still the advantages of this mode of assemblage are so great, as to insure its preference in mining operations, and many other applications.

The drawings (which are numbered onward from the commencement of the set presented to the Institution, in the session of 1838*), display the entire machine, with details of all the parts.

The following original communications were announced as received:—

"Report upon the experimental Brick Cylinders laid down in the River Thames, at Rotherhithe, in the year 1811, for the purpose of ascertaining the practicability of forming a Tunnel under the river." By John J. Hawkins, M. Inst. C. E.

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* *Minutes of Proceedings*, 1838, page 39.

The Drawings illustrating this communication, by Thomas Chalmers, Grad. Inst. C. E.

"On the use of the Eccentric, with an appropriate Slide, to cut off the steam in Expansive Steam Engines;" with two Drawings. By E. F. White.

"Table of Experiments made with various kinds of Coal." By W. Tierney Clark, M. Inst. C. E.

"Tabulated Statements of the performances of the English and American Engines; and of the daily performances of the Bank Engines, on the Lickey Incline Plane on the Birmingham and Glo'ster Railway, from October 17th, 1840, to March 20th, 1841." By Captain Moorsom, Assoc. Inst. C. E.

"An Account of the Quarries under the city of Paris, and the Walls built within them for the support of the houses." By Charles Manby, Assoc. Inst. C. E. Secretary.

"Method of using the direct power of a horse upon a Tread Wheel, to propel a Carriage." By Edward Chapman.

"Memoir of Captain Huddart." By William Cotton.

"Description of a Machine for Wetting Bricks, used on the Hereford and Gloucestershire Canal;" with a Drawing; communicated by the President. By Stephen Ballard, Assoc. Inst. C. E.

"A Critical Investigation of some portions of Pambour's Practical Treatise on Locomotive Engines upon Railways." By the Rev. W. M. Lawson; communicated by Captain Vetch, Assoc. Inst. C. E.

" Description of a Blast Furnace at the Butterley Iron Works, blown with Hot Blast, and working with raw Coal; with an account of the burthen and yield;" with a Drawing. By S. C. Kreeft, Grad. Inst. C. E.

" A Mode of using Vertical Joggles for securing stone work in Lighthouses, &c.;" with a Model. By R. Townsend, Assoc. Inst. C. E.

" Description of two Double Acting Steam Engines of 50 horses power erecting in Egypt;" with five Drawings. By J. A. Galloway, M. Inst. C. E.

" A Description and Drawings of a Mill, Forge, and Furnaces, designed for an Iron Work in South Wales." By T. G. Hardie, Assoc. Inst. C. E.

" Account of the Machinery and Apparatus for compressing and using Gas for artificial illumination at the Portable Gas Works of London, Edinburgh, Manchester, and Paris;" with five Drawings. By C. Denroche, Grad. Inst. C. E.

" Description of the Water Pressure Engine at Illsang, in Bavaria;" with one Drawing. By W. L. Baker, Grad. Inst. C. E.

" On the Strength of Carriage Bodies, as affecting the safety of Railway Travelling;" with three Drawings. By U. P. Macquorn Rankine.

" Description of a Machine for proving Railway Bars, and of a Deflectometer for ascertaining the depression of Rails during the passage of the Train of Carriages;" with two Drawings. By J. Atwell.

" Description of the Roof of Messrs. Simpson and Co.'s Engine Factory at Pimlico;" with one Drawing. By J. Boustead, Grad. Inst. C. E.

" Description of Chelson Meadow Sluice;" with one Drawing. By Thomas Budd, Grad. Inst. C. E.

" Description of the North Entrance of the Menai Strait, showing the Lighthouse, Beacon, &c. ;" with one Drawing. By D. P. Hewett, Grad. Inst. C. E.

" Description of the Ponte della Maddelina over the river Serchio, between Lucca and the Bagni caldi di Lucca, Italy ;" with an Engraving. By R. Townshend, Assoc. Inst. C. E.

" On the permanent way of the Birmingham and Gloucester Railway ;" with four Drawings. By G. B. W. Jackson, Grad. Inst. C. E.

" On the causes of, and means of preventing, the priming in Steam Boilers." By S. C. Homersham, Assoc. Inst. C. E.

" Description of Part of the Works of the Ulster Canal ;" with three Drawings. By T. Casebourne, M. Inst. C. E.

" Description of the Panchrestomer (or all-useful rule), for supplying to a certain extent the uses of many of the principal instruments employed by the Civil Engineer and scientific man, in the operations of surveying, observation, measurement, calculating, drawing, &c. &c." By William Pole, Assoc. Inst. C. E.

" On Condensation by Re-injection." By Thomas Howard, Assoc. Inst. C. E.

" Description of a Machine for Sawing Slate ;" with one Drawing. By Thomas Ainger.

" Description of a Model of Arthur's Seat, Edinburgh ;" with a Model. By J. R. Wright.

" Observations relative to the formation of Docks at the Port of London, and a Description of the Works of the London Docks ;" with fifteen Drawings. By Robert Richardson, Grad. Inst. C. E.

"An Experimental Inquiry concerning the relative power of, and useful effect produced by, the Cornish, and Boulton and Watt Pumping Engines, and Cylindrical and Waggon Head Boilers." By Thomas Wicksteed, M. Inst. C. E.

The Meeting of the Institution was then adjourned to the second Tuesday in January, 1842.

TELFORD AND WALKER PREMIUMS.

SESSION, 1842.

The Council invite communications on the following as well as other subjects for Telford and Walker promiums:—

1. The alterations and improvements in Blackfriars Bridge.
2. A Description of the Katwyk Dykes; the Canal of the Helder; or of any similar Foreign Engineering works of equal importance.
3. The modes of Drainage adopted in the Lowlands of the United Kingdom, or works of a similar nature in Holland, or in other countries.
4. On any of the principal Rivers of the United Kingdom: describing their Physical Characteristics, and the Engineering works upon them.
5. The various kinds of Limes and Cements employed in Engineering works.
6. The resistance to Aeriform Fluids in their passage through Pipes or Conduits at different velocities.
7. The conveyance of Fluids in Pipes, under Pressure, and the circumstances which usually affect the velocity of their currents.
8. The means of rendering large Supplies of Water available for the purpose of extinguishing Fires.
9. The construction of large Chimneys, as affecting their Draught; with examples and drawings.
10. The comparative advantages of Wire and Hempen Ropes.
11. The relative merits of Granite and Wood Pavements, derived from actual experience.
12. The ascertained effects of any method for preserving Timber from decay.

13. The Smelting and Manufacture of Iron, either with Hot or Cold Blast.
14. The Smelting and Manufacture of Copper.
15. The comparative advantages of Iron and Wood, or of both materials combined, as employed in the construction of Steam Vessels; with drawings and descriptions.
16. The sizes of Steam Vessels of all classes, whether River or Sea-going, in comparison with their Engine Power: giving the principal dimensions of the engines and vessels, draught of water, tonnage, speed, consumption of fuel, &c.
17. The various mechanism for propelling Vessels, in actual or past use.
18. The causes, means of preventing, and methods of determining, the amount of priming in Steam Boilers.
19. The description of any Meter in practical use for accurately registering the quantity of Water for supplying Steam Boilers, or for other purposes.
20. The explosion of Steam Boilers; especially a record of facts and evidence connected with any well-authenticated cases; also a description, drawings, and details, of the Boilers, both before and after the explosion.
21. The various modes adopted for moving Earth in Railway Tunnels, Cuttings, or Embankments, with the cost thereof.
22. On Stone Blocks and Timber Sleepers or Sills, with or without continuous Bearings, for Railways.
23. The results of experience as regards the consumption of Power for a given effect, on Railways having different widths of Gauge; with the advantages or disadvantages attributable to any established width of Gauge.
24. Memoirs, and Accounts of Works and Inventions of any of the following Engineers:—Sir Hugh Middleton; Arthur Woolf; Jonathan Hornblower; Richard Trevithick; and ~~Sir~~ William Murdoch (of Soho).

The Communications must be forwarded, on or before the 31st of May, 1842, to the House of the Institution, No. 25, Great George Street, Westminster, where copies of this paper, and any further information, may be obtained.

CHARLES MANBY,
Secretary.

25, *Great George Street*, *Westminster*, 1841.

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